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STATISTICAL EVALUATION OF THE EFFECTIVENESS OF CHILD RESTRAINTS

Report No. 4 of 7

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FINAL REPORT

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Prepared for the National Highway Traffic Safety Administration in support of a program to review existing regulations, as required by Executive Order 12044 and Department of Transportation Order 2100.5. Agency staff will perform and publish an official evaluation of Federal Motor Vehicle Safety Standard 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 is the Final Report for the statistical evaluation of the effectiveness of child restraint systems, which are regulated by Federal Motor Vehicle Safety Standard (FMVSS) 213. It is one of seven statistical evaluations to be conducted under this contract. The seven Standards are:

1. FMVSS 108: Side Marker Lamps (only)
2. FMVSS 202: Head Restraints
3. FMVSS 207: Seat Back Locks (only)
4. FMVSS 213: Child Seating Systems
5. FMVSS 214: Side Door Beams
6. FMVSS 222: School Bus Seating and Crash Protection
7. FMVSS 301: Fuel System Integrity

FMVSS 213 is a death-and-injury reduction Standard which mandates static tests, labeling, and other requirements which manufacturers of child seats must meet. The Standard became effective April 1, 1971. Action is pending on proposed revisions.

The objective of the analysis is to determine the overall effectiveness of child restraints when used, rather than to evaluate FMVSS 213 in particular. This required an analysis of subsets of mass accident data involving 4 year old and younger child occupants of known injury level, seating position and restraint usage in passenger cars. Evaluations were based on 21,837 cases in New York (1974, 1977), 6,738 cases in New Jersey (1975) and 3,766 cases in Idaho (1976-1978). Contingency table data were subjected to log-linear modeling and adjustment to minimize potential confounding effects and allow direct comparison of injury rates between children using child restraints, children using seatbelts, and unrestrained children.

The results clearly show that accident-involved children restrained by either child restraints or seatbelts sustain significantly fewer injuries than unrestrained children. In the largest sample, New York, child restraint usage results in a 30 percent reduction in KABC injuries, a 26 percent reduction in KAB injuries, and a 28 percent reduction in KA injuries. In New York, the overall effectiveness values for child restraint use and seatbelt use are about the same for KABC injuries, although for KAB and KA injuries, seatbelt effectiveness values are 1.5 to 2 times higher than child restraint effectiveness values. In New Jersey and Idaho, the effectiveness values for seatbelt use are generally 2.5 to 3 times higher than those for child restraint use. Differences between child restraint and seatbelt effectiveness values, however, are statistically significant only for the New Jersey sample.

On a nationwide basis, if 100 percent usage of child seats were assumed, about 12,000 injuries and 150 fatalities could be prevented in children two years of age and younger. These figures most likely underestimate the potential reduction in both the frequency and severity of injuries to be gained from the proper use of FMVSS 213 child restraints, since the computed effectiveness values are based on child seats which may not have met FMVSS 213 requirements or which may have been misused.

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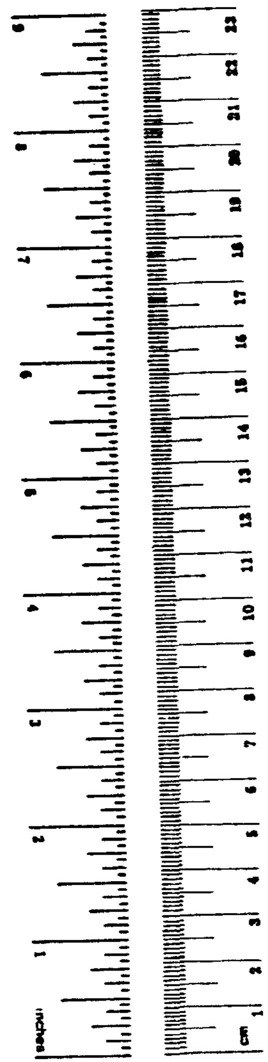
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

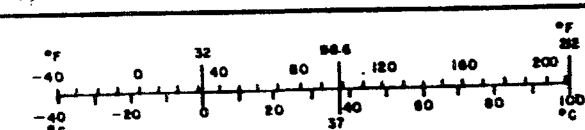
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	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



EXECUTIVE SUMMARY

This is the Final Report of the statistical evaluation of the effectiveness of child restraint systems, which are regulated by Federal Motor Vehicle Safety Standard (FMVSS) 213.

FMVSS 213 is a death-and-injury-reduction Standard which, in its present form (September 1980), mandates static tests, labeling, and other requirements that must be met by manufacturers of child restraint devices. The Standard became effective 1 April 1971. Proposed revisions to the Standard, which will require dynamic testing of all child restraints and will include previously-exempt car beds, infant carriers and child harnesses, are expected to become effective 1 January 1981.

The objective of this analysis is to determine the overall effectiveness of child restraints when used rather than to evaluate FMVSS 213 in particular. Existing mass accident data from New York (1974 and 1977), Idaho (1976-1978) and New Jersey (1975) are statistically evaluated. These data do not provide information on the type or make of the child restraint, or whether the restraint is properly installed and correctly used.

To address the question of whether or not child restraint usage reduces the frequency or severity of child injuries, a comparison is made between the injury rates of children four years old and younger reported as using a child seating system, with those of children who are unrestrained, after controlling for relevant accident characteristics. By inference, any obtained differences in these rates are attributed to the effect of the restraining device. Essentially, unrestrained children are treated as a control group. Thus, effectiveness can be defined as follows:

$$E = \left[\frac{\text{Proportion of unrestrained children injured} - \text{Proportion of restrained children injured}}{\text{Proportions of unrestrained children injured}} \right] \times 100$$

Estimates of effectiveness are computed separately for both child restraint and seat belt usage, so that the percent reduction in injuries due to the former can be compared to any corresponding reduction in injury associated with the latter.

Before effectiveness values are computed, however, the data are modeled by fitting a hierarchical, log-linear model to a contingency table composed of Injury, Restraint Usage and selected variables. The purpose of modeling is to smooth the data and to remove random variability due to small cell frequencies that occur when a large number of control variables are used. Modeling also reveals the strength of various interactions among the variables. For each year of New York data, separate models are fit for KA vs. BCO, KAB vs. CO and KABC vs. 0 injury dichotomies. For New Jersey, only the latter two models are fit, while in the case of Idaho, only one model for the KABC vs. 0 injury dichotomy is fit. This is due to the small sample sizes for the latter two states. The smoothed cell frequencies are then adjusted to allow for the direct comparison of injury rates. Adjustment is necessary in order to insure that the overall effectiveness estimates will not be affected by different distributions of children in child restraints, seat belts and unrestrained categories across different levels of the control variables.

Overall effectiveness values for children in child restraints, seatbelts and children restrained by either device for the smoothed, adjusted mass accident data in the three states are summarized in the following table. The effectiveness results for New York consist of a weighted average of the individual effectiveness values for 1974 and 1977 samples (10,745 and 11,092 cases). The effectiveness results for New Jersey and Idaho are based on sample sizes of 6,738 and 3,766 cases, respectively. Only statistically significant effectiveness findings are discussed.

In all instances, statistically significant findings show that accident-involved children restrained by either child restraints or seatbelts sustain significantly <u>fewer</u> injuries than unrestrained children. For example, the percent reduction in the number of injuries sustained by restrained children is:

- Killed and all injuries (K+A+B+C) = 30 to 37 %
- Killed and all but minor injuries (K+A+B) = 32 to 44 %
- Killed and severe injuries (K+A) = 41 %

When child restraint systems are considered separately, most of the findings are statistically significant. In New York, for example, child restraint usage results in a 28 percent reduction in K and A injuries and a 26 percent reduction in the overall incidence of K, A and B injuries, compared to a 30 percent reduction in K, A, B and C injuries considered collectively. In New Jersey, child restraint usage results in a 20 percent reduction in overall K, A, B and K, A, B and C injuries.

SUMMARY OF OVERALL EFFECTIVENESS VALUES FOR CHILDREN 0-4 YEARS* OF AGE DERIVED FROM SMOOTHED, ADJUSTED MASS ACCIDENT DATA

Restraint	Injury Level	State	Year	Effectiveness (%)	Is Effectiveness Significantly Different From Zero?
Child Restraint	K+A	New York	1974 & 1977	27.5	Yes
	K+A+B	New York New Jersey	1974 & 1977 1975	25.9 19.2	Yes Yes
	K+A+B+C	New York New Jersey Idaho	1974 & 1977 1975 1976-1978	30.1 19.8 12.7	Yes Yes No
Seatbelt	K+A	New York	1974 & 1977	53.5	Yes
	K+A+B	New York New Jersey	1974 & 1977 1975	35.8 60.5	Yes Yes
	K+A+B+C	New York New Jersey Idaho	1974 & 1977 1975 1976-1978	29.7 48.4 37.7	Yes Yes Yes
Child Restraints or Seatbelts	K+A	New York	1974 & 1977	42.9	Yes
	K+A+B	New York New Jersey	1974 & 1977 1975	31.8 43.8	Yes Yes
	K+A+B+C	New York New Jersey Idaho	1974 & 1977 1975 1976-1978	29.7 36.8 30.4	Yes Yes Yes

*In New Jersey and Idaho, the age range of children is 1-4 years old.

While effectiveness values for seatbelt usage are generally one to two times higher than those for child restraint usage, one must be wary of attaching too much importance to this result, since the differences are not statistically significant, except in the case of New Jersey. Furthermore, the lack of detail characterizing state mass accident data bases with respect to the actual type of child restraint device used, and whether they are properly used or misused, cause the findings of this study to most likely underestimate the potential reduction of both the frequency and severity of injuries to be gained from the proper use of FMVSS 213 child restraints.

The actual and potential reduction in injuries and fatalities for children two years old and younger, for the entire nation, that result from the use of child restraints were estimated using the actual weighted New York effectiveness value of 30 percent derived using the KABC vs O injury dichotomy. Child restraint usage rates of 20 percent, 10 percent and 5 percent were assumed for less than 1 year old, 1 year old and 2 year old children, respectively. With these low usage rates, it is estimated that roughly 1400 injuries and 19 fatalities are prevented in children of this age, through the use of child seats. If 100 percent usage of child seats were assumed, about 12,000 injuries and 150 fatalities could be prevented in children two years of age and younger.

ACKNOWLEDGMENTS

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

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

Mr. Thomas Bzik
Dr. Hans Joksch (Appendix E)
Mr. Edward Sweeton
Mr. Joseph Reidy
Dr. Michael Sutherland

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

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ABBREVIATIONS USED

FMVSS	Federal Motor Vehicle Safety Standard
CEM	The Center for the Environment and Man, Inc.
HSRC	Highway Safety Research Center
NHTSA	National Highway Traffic Safety Administration
NASS	National Accident Sampling System
KABCO	"K" = Killed; "A", "B", "C" = Injury Levels; "O" = No Injury
NCSS	National Crash Severity Study
FARS	Fatal Accident Reporting System
LR	Likelihood Ratio
BMDP3F	Biomedical Computer Program 3F
df	Degrees of Freedom

1.0 INTRODUCTION

1.1 Background

This is the fourth in a series of reports of the statistical evaluation of the effectiveness of seven Federal Motor Vehicle Safety Standards (FMVSS). This work was conducted under Contract DOT-HS-8-02014 by The Center for the Environment and Man, Inc. (CEM) and its subcontractor, the Highway Safety Research Center (HSRC) of the University of North Carolina. The seven FMVSS which were statistically evaluated are:

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

The Final Report on the effectiveness of child restraints is presented herein.

FMVSS 213 is a unique Standard. Its effectiveness depends on voluntary use of child restraints. Unlike the other Standards evaluated in this study, it applies to devices which are optional equipment. Unlike the reports on the six other FMVSS, this report evaluates child restraints in general, rather than the Standard (213) in particular.

FMVSS 213 became effective April 1, 1971; it established requirements for labeling, installing, adjusting and attaching child seating systems to vehicle seat belts. It also required manufacturers to produce child restraints which met a static test at a force level of 1,000 pounds--which translates to about 15 miles per hour in a traffic crash. In March 1974, the National Highway Traffic Safety Administration (NHTSA) proposed a revision which would expand the scope of the Standard to cover all forms of infant and child restraints(child seats, car beds, infant carriers and child harnesses); require dynamic crash simulation tests of the restraints rather than the present static tests; and specify the anthropomorphic test dummies to be used in the tests. In May 1978, NHTSA published a modified proposal for a revised child restraint system Standard "based on recent child restraint misuse studies and a desire to improve usage of child restraints while improving safety,and an evaluation of the comments concerning the 1974 proposal." [1]

NHTSA's amended regulations are scheduled to take effect on January 1, 1981. [2] The broadened Standard will include previously-exempt car beds, child harnesses and infant carriers. All child restraints must:

- Offer adequate protection in 30 mph crash tests into a fixed barrier by:
  - Restraining the test dummy.
  - Keeping the system's structural integrity.
- Be designed to be held in place by the vehicle's seat belts.
  - Special tether straps will be allowed (in addition to the seat belt), but a minimum level of protection must be met using the seat belt even when the tether is not fastened.

It became obvious that a strict evaluation of FMVSS 213 *as it existed during the period of the CEM study*, would offer little information on the overall effectiveness of child restraints in reducing injuries to young children involved in car crashes. The study became, therefore, a broader, more general evaluation of the effectiveness of child restraints when they are used.

There are two major problems with using police-reported state mass accident data to evaluate child restraint effectiveness. First, misuse of child restraints is a major concern, insofar as police-reported data do not identify whether a restraint was properly used, only that it was used. Second, state accident data do not discriminate among the many types of "child restraints." For example, data on children in "infant seats" and car beds may be mixed with data on children in approved, properly-secured child restraint devices. These two issues are discussed next.

Misuse of Child Restraints

One of the pertinent issues raised by NHTSA in its 1978 Standard revision publication was whether its amendments adequately addressed the misuse problem. During an international conference in Australia in 1977, the author of a survey on installing child restraints reported that:

> "Casual observation of child restraints in automobiles indicated that a significant proportion were incorrectly installed, and that a study was warranted to determine the extent of the problem.
>
> "The major potential faults considered were as follows: straps not connected; straps not tightened; and poorly located anchorage points. The study found that only about 19% of child motor vehicle occupants are correctly restrained in approved child restraints. It was concluded that efforts must be made among manufacturers, installers and consumers to insure that child restraints be properly installed." [3]

A recent study sponsored by the Insurance Institute for Highway Safety (IIHS) reported only 4.7 percent of 494 young children were restrained by either vehicle lap belts or child restraints. Only one-third of the devices in use during crashes were used properly. The study said incorrect usage of child restraint systems increased injury potential (e.g., failing to use the car lap belt to secure the restraint device and failing to use the restraint device's safety harness). Among the properly restrained children there was only one minor injury.[4] In an earlier IIHS study, 7 percent of 8,993 children under ten years of age were restrained--5 percent by seatbelt only and 2 percent by a child restraint device. An additional 5 percent of the children were in child restraints which were not properly secured in the vehicle and/or the children were not properly restrained within the device. According to this study, whatever crash protection child restraints provide is either "reduced or eliminated" if they are not used correctly.[5]

IIHS's most recent study provided a detailed analysis of 48 crashes involving 63 children under nine years of age, out of an original population of 348 crashes involving 494 children. It was found that:

> "There is still the problem of proper use. One of the disconcerting things found in our study is that in those small number of cases in which a child restraint was present and in use, very few of those child restraints were being used correctly. People go to the trouble of buying them, then don't use them correctly, either because they are in a hurry or they just don't know that they are not anchoring them effectively." [6]

Inclusion of Restraints Failing to Meet FMVSS 213 in Data Base

CEM's initial survey of state accident reporting forms indicated that most states do not record the use or non-use of child restraints and, where data are taken, the reports lack detail. Among those states which do record child restraint usage, the coding forms do not differentiate between various types of child restraint systems; therefore, car beds, infant carriers, and child harnesses*, none of which are currently covered by the requirements of FMVSS 213, are included in the data base. In addition, since few police officers are trained in assessing what is an appropriate, approved child restraint, it is probable that the data bases also include some restraints,

*Type 3 seat belt assemblies, commonly referred to as child harnesses, are presently under FMVSS 209 (Seat Belt Assemblies). They are a combination of pelvic and upper torso restraints for persons weighing up to 50 pounds and capable of sitting upright by themselves--that is, children approximately 8 months to 6 years old. Car beds and infant carriers are not covered by any present Federal Motor Vehicle Safety Standard, but will be covered under the revised FMVSS 213.

such as the earlier hook-over car seats, which are now outlawed by the Standard. IIHS's 1975 report on child restraint use stated that, "Many of the devices that are used to transport children in vehicles provide no crash protection, e.g., 'car seats' that hook over regular automobile seats...and other seats and carriers designed in ways that ensure that they do not protect children in crashes." [5]

1.2 Objective and Purpose

This report is an analysis of child restraint systems in general, to determine whether or not their effectiveness (regardless of type or proper use) can be determined from statistical analyses of existing mass accident data.

This evaluation cannot be considered an evaluation of FMVSS 213 in particular, for reasons described in the preceding section. Rather, its purpose is to either assess the effectiveness of child restraints with respect to injury avoidance, or to demonstrate that existing mass accident data are not adequate for such purposes. Suggestions for a further evaluation program, developed earlier, are described in References 7 and 8.

1.3 Scope

- This study involves the statistical analysis of state mass accident data concerning deaths and injuries incurred in automobile accidents by children four years of age or less, including both those who are unrestrained, those in child restraint systems, and those restrained by seat belts.
- Analysis of detailed National Crash Severity Study (NCSS) data are not carried out, since about 50 children (of approximately 10,000 available cases) are coded as using child restraints.
- The mass accident data used are those from New York (1974 and 1977), Idaho (1976-1978) and New Jersey (1975).
  - Only one year of New Jersey data is used, since there is no child restaint usage information available for 1976, and there appear to be severe miscoding problems in 1977 with respect to child restraint usage.
- The analysis emphasizes comparison of child injury rates with respect to the use or non-use of child restraints. Given sample size limitations, an effort is made to refine the analyses by controlling for concomitant variables, such as position of the child in the car, direction of force from impact, accident severity, child's age, accident type, etc.

1.4 Approach

1.4.1 Background and Accident Data Populations

The statistical evaluation of the effectiveness of child restraints is based on the comparison of injury rates of children using a child restraint system with those of unrestrained children, after controlling for relevant accident characteristics. Specifically, simple displays of Injury Level by Child Restraint Usage are stratified for various combinations of conditioning variables, such as front or back seat occupancy, age of child, severity of accident, single or multivehicle accident, front, side or rear-impact accidents, etc. Hence, the question of overall effectiveness as well as the effectiveness of specific subpopulations can be addressed. Table 1-1 summarizes the estimated population sizes for the various data sources.

TABLE 1-1

ESIMATED NUMBER OF ACCIDENTS INVOLVING A CHILD (AGE 0-4)* AS VEHICLE OCCUPANT

Year	New York			New Jersey			Idaho		
	Children in Accidents	Children in Restraints		Children in Accidents	Children in Restraints		Children in Accidents	Children in Restraints	
	No.	No.	%	No	No.	%	No.	No.	%
1974	14,148	931	7	-	-	-	-	-	-
1975	-	-	-	7543	764	10	-	-	-
1976	-	-	-	-	-	-	1457	79	5
1977	14,215	1081	8	7500	**25	0.3	1493	84	6
1978	-	-	-	-	-	-	1718	104	6

*In New Jersey and Idaho, the age range of children is 1-4 years.

**Low value is due to serious miscoding problem in New Jersey with respect to child restraint usage in 1977. Therefore, 1977 data could not be used.

1.4.2 Analysis Approach

The use of child restraints should reduce the frequency of injuries to children in car accidents. However, because we know that child restraints are frequently misused and that not all child "restraints" can meet the requirements of the Standard (revised), the results of our analysis reflect a combination of factors. In addition to analyzing the effectiveness of those devices reported by police as child restraints, we also analyze the effectiveness of reported seat belt use for comparison with child restraint effectiveness.

Our general approach is to perform a categorical data analysis, using mass accident data from New York, Idaho, and New Jersey. This involves selecting the critical variables, modeling the data and adjusting the modeled data in order to make unbiased comparisons, using injury as the dependent variable.

1.5 Limitations of the Study

The evaluation of child restraints is limited by the small size of the restraint users sample. The usage of child restraints is voluntary, and studies have shown that the usage rate of child restraints is 20 percent or less. Furthermore, relatively few young children are occupants of vehicles involved in accidents. For the most part, states do not record the use or non-use of child restraining devices (other than seat belts) in their police accident reports, so the analysis had to be limited to states that do record it. Hence, state mass accident data alone are not always sufficient to establish effectiveness with a suitable degree of statistical significance. National Crash Severity Study (NCSS) data, while providing more detail, include about 50 children in child restraints, thus offering no opportunity for analysis.

Another limitation involves the fact that state mass accident data do not differentiate between various types of child restraints, nor do they indicate the restraint's appropriateness with respect to a child's age and height, or whether the restraint is properly used. Thus, any observed effectiveness of child restraints in reducing injury that is derived from police-reported state accident data is probably an underestimate of the effectiveness of properly-used FMVSS 213 child restraints.

1.6 Outline of the Report

Section 2 of this report summarizes the analyses performed. It includes a discussion of the measure of effectiveness, the estimated effectiveness values and their confidence intervals, discussions of the overall success of the evaluation, the credibility of the analysis, and a comparison of results. Detailed analyses of the data are described in Section 3. Appendix A summarizes background characteristics of the New York, Idaho and New Jersey samples. Appendix B contains the fully cross-classified contingency tables derived from the state mass accident data bases. Appendix C summarizes the effects included in the various models fitted, along with their marginal associations. Appendix D contains a summary of effectiveness values derived from observed, unadjusted data. Appendix E outlines the method used for computing confidence limits for effectiveness estimates based on the ratio of injury probabilities.

1.7 References for Section 1

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8. Northrop, G.M., J.T. Ball, D. Bancroft and J.C. Reidy. *Evaluation Methodologies for Nine Federal Motor Vehicle Safety Standards: FMVSS 105, 108, 122, 202, 207, 213, 220, 221, 222*, DOT-HS-803 388, National Technical Information Service, Springfield, Virginia, 1978.

2.0 SUMMARY OF ANALYSIS

2.1 Measure of Effectiveness

The effectiveness measure used in the study is defined as follows.

$$E = \left[\frac{\text{Proportion of unrestrained children injured} - \text{Proportion of restrained children injured}}{\text{Proportion of unrestrained children injured}} \right] \times 100$$

Effectiveness values are computed separately for three restraint usage conditions--child restraints, seat belts, and usage of either device.

2.2 Estimated Effects of Child Restraints

The estimated effectiveness of child restraints can be potentially confounded by three factors: (1) the accuracy of police reporting on the use of a child restraint, (2) the potential variety of types of child restraints in use during the years analyzed (1974-1978), including infant carriers, car beds, etc.--some of which presumably do not meet the safety requirements of FMVSS 213, and (3) the frequent misuse of child restraints. The effects of the latter two factors might result in effectiveness values that are probably less than what would be obtained for children correctly restrained in child seats that meet the requirements of FMVSS 213.

The effectiveness values for child restraints, seat belts and both child restraints and seat belts derived from observed, unadjusted as well as from smoothed, adjusted mass accident data in New York, New Jersey and Idaho are summarized in Table 2-1. The effectiveness results for New York are for children of age ranges 0-4 years old and represent a weighted average of effectiveness values for 1974 and 1977 (10,745 cases and 11,092 cases). The effectiveness results for New Jersey and Idaho are for children in the age range 1-4 years old and are for the years 1975 and 1976-1978 (6,738 cases and 3,766 cases).

The term "smoothed, adjusted" refers to data which has been first modeled in order to remove random variation due to small contingency table cell frequencies for certain categories of control variables, and then standardized to allow for valid comparisons to be drawn between injury rates for various subpopulations. On the average, the net effect of smoothing and adjusting the data was to decrease effectiveness values by roughly 1 to 5 percentage points for New York samples, and to increase effectiveness values by 4 to 8 percentage points for the Idaho sample. In the case of the New Jersey sample, modeling and adjustment had no appreciable impact on effectiveness values.

TABLE 2-1

SUMMARY OF OVERALL EFFECTIVENESS VALUES FOR CHILDREN 0-4 YEARS OF AGE*
DERIVED FROM MASS ACCIDENT DATA

Restraint	Injury Level	State	Year	Observed, Unadjusted Data: Effectiveness (Percent)	Standard Deviation	95 % Confidence Interval: From	To	Is Effectiveness Significantly Different From Zero?
Child Restraint	K+A	New York	1974 & 1977 **	32.2	12.9	11.1	53.3	Yes
	K+A+B	New York	1974 & 1977 **	26.6	4.8	18.8	34.4	Yes
		New Jersey	1975	18.0	10.1	1.4	34.6	Yes
	K+A+B+C	New York	1974 & 1977 **	31.9	3.5	26.2	37.6	Yes
		New Jersey	1975	19.8	5.5	10.8	28.8	Yes
		Idaho	1976-1978	4.6	18.5	-25.8	34.9	No
Seat Belt	K+A	New York	1974 & 1977 **	54.6	8.6	40.5	68.7	Yes
	K+A+B	New York	1974 & 1977 **	37.6	3.7	31.6	43.6	Yes
		New Jersey	1975	60.5	5.9	51.0	70.2	Yes
	K+A+B+C	New York	1974 & 1977 **	31.5	2.9	26.8	36.3	Yes
		New Jersey	1975	47.4	3.9	41.0	53.7	Yes
		Idaho	1976-1978	41.3	9.8	25.2	57.4	Yes
Child Restraint or Seat Belt	K+A	New York	1974 & 1977 **	45.5	7.6	33.1	57.9	Yes
	K+A+B	New York	1974 & 1977 **	33.1	3.0	28.1	38.0	Yes
		New Jersey	1975	43.3	5.6	34.1	52.5	Yes
	K+A+B+C	New York	1974 & 1977 **	31.4	2.3	27.6	35.1	Yes
		New Jersey	1975	36.2	3.3	30.7	41.6	Yes
		Idaho	1976-1978	30.5	9.0	15.7	45.3	Yes

*In New Jersey and Idaho, the age range of children is 1-4 years old.

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

TABLE 2-1 (Continued)

Restraint	Injury Level	State	Year	Smoothed, Adjusted Data: Effectiveness (Percent)	Standard Deviation	95 % Confidence Interval: From	To	Is Effectiveness Significantly Different From Zero?
Child Restraint	K+A	New York	1974 & 1977 **	27.5	13.3	5.6	49.4	Yes
	K+A+B	New York	1974 & 1977 **	25.9	4.8	18.0	33.8	Yes
		New Jersey	1975	19.2	10.0	2.7	35.7	Yes
	K+A+B+C	New York	1974 & 1977 **	30.1	3.5	24.3	35.9	Yes
		New Jersey	1975	19.8	5.5	10.8	28.8	Yes
		Idaho	1976-1978	12.7	17.8	-16.5	42.0	No
Seat Belt	K+A	New York	1974 & 1977 **	53.5	8.7	39.2	67.7	Yes
	K+A+B	New York	1974 & 1977 **	35.8	3.7	29.7	42.0	Yes
		New Jersey	1975	60.5	5.9	50.9	70.1	Yes
	K+A+B+C	New York	1974 & 1977 **	29.7	2.9	24.9	34.4	Yes
		New Jersey	1975	48.4	3.8	42.1	54.6	Yes
		Idaho	1976-1978	37.7	10.1	21.2	54.3	Yes
Child Restraint or Seat Belt	K+A	New York	1974 & 1977 **	42.9	7.8	30.2	55.7	Yes
	K+A+B	New York	1974 & 1977 **	31.8	3.1	26.8	36.8	Yes
		New Jersey	1975	43.8	5.6	34.6	53.0	Yes
	K+A+B+C	New York	1974 & 1977 **	29.7	2.3	25.8	33.5	Yes
		New Jersey	1975	36.8	3.3	31.4	42.2	Yes
		Idaho	1976-1978	30.4	9.1	15.5	45.2	Yes

*In New Jersey and Idaho, the age range of children is 1-4 years old.

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

In all instances, findings show that accident-involved children restrained by either child restraints or seat belts sustain significantly fewer injuries than unrestrained children. For example, the percent reduction in the number of injuries sustained by restrained children ranges from 30 to 37 percent for K, A, B and C injuries; 32 to 44 percent for K, A, and B injuries; and is 41 percent for K and A injuries.

When child restraint systems are considered separately, most of the findings are statistically significant. For example, in New York, child restraint usage results in a 28 percent reduction in K and A injuries and a 26 percent reduction in the overall incidence of K, A and B injuries, compared to a 30 percent reduction in K, A, B and C injuries, considered collectively. In New Jersey, child restraint usage results in a 20 percent reduction in overall K, A, B and K,A, B and C injuries.

While effectiveness values for seat belt usage are generally one to two times higher than those for child restraint usage, one must be wary of attaching too much importance to this result, since the differences are not statistically significant in most cases. The only exception to this involves the New Jersey 1975 sample, where seat belts are significantly more effective in reducing KAB and KABC injuries than child restraints (Table 2-2). Furthermore, the lack of detail characterizing state mass accident data bases with respect to the actual

TABLE 2-2

STATISTICAL SIGNIFICANCE* OF DIFFERENCES BETWEEN SEAT BELT AND CHILD RESTRAINT EFFECTIVENESS VALUES DERIVED FROM SMOOTHED, ADJUSTED MASS ACCIDENT DATA

Injury Level	State	Year	Seat Belt Effectiveness		Child Restraint Effectiveness		Difference		Is Difference Statistically Significant?
			(%)	(s.d)	(%)	(s.d)	(%)	(s.d)	
K+A	New York	1974 & 1977**	53.5	8.7	27.5	13.3	26.0	15.9	No
K+A+B	New York	1974 & 1977**	35.8	3.7	25.9	4.8	9.9	6.1	No
	New Jersey	1975	60.5	5.9	19.2	10.0	41.3	11.6	Yes
K+A+B+C	New York	1974 & 1977**	29.7	2.9	30.1	3.5	-0.4	4.6	No
	New Jersey	1975	48.4	3.8	19.8	5.5	28.6	6.7	Yes
	Idaho	1976-1978	37.7	10.1	12.7	17.8	25.0	20.5	No

*Two-tailed test, $\alpha = 0.05$

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

type of child restraint device used, and whether they are properly used or misused, cause the findings of this study to most likely underestimate the potential reduction of both the frequency and severity of injuries to be gained from the proper use of FMVSS 213 child restraints.

The actual and potential reductions in injuries and fatalities for children two years old and younger, for the entire nation, that result from the use of child restraints, were estimated using the actual weighted New York effectiveness value of 30 percent derived using the KABC vs 0 injury dichotomy. Current (September 1980) child restraint usage rates of 20 percent, 10 percent and 5 percent were assumed for 0 year old, 1 year old and 2 year old children, respectively. With these low usage rates, it is estimated that roughly 1400 injuries and 19 fatalities are prevented in children of this age through the use of child seats. If 100 percent usage of child seats were assumed, about 12,000 injuries and 150 fatalities could be prevented in children 2 years of age and younger. The above estimate, however, reflects both the current degree of correct usage of child seats and the particular type of child seats in use, including those that do not meet the requirements of FMVSS 213.

2.3 Evaluation of the Analysis

2.3.1 Overall Success of the Analysis

The effectiveness results which were summarized in Table 2-1 and discussed in the previous section conclusively demonstrate the positive effectiveness of child restraints and seat belts in reducing injuries to children four years of age or younger. These results are obtained in spite of recognized problems in police reporting of child seat usage, inclusion in the data of child seats which do not meet FMVSS 213 requirements, and the possible misuse of child seats in general. The 30 percent effectiveness value that was used to estimate the potential injuries avoided through the use of child restraints is almost certainly a lower bound for the "true" effectiveness that would be obtained given the correct use of child restraints that satisfy FMVSS 213, and fully accurate police reporting.

2.3.2 Limitations of the Analysis

Three potential limitations to the study have already been mentioned. These are: (1) inadequate reporting of child restraint usage, (2) inclusion of child restraints in the data base that fail to meet FMVSS 213, and (3) misuse of child restraints. In addition, limitations that apply to the New Jersey and Idaho data bases are the absence of infants less than one year old and the relatively small sample sizes. Finally, the analysis was limited to data from the few states that code child restraint use.

2.3.3 Credibility of the Analysis

The results are credible. In the larger New York and New Jersey data bases, child restraints showed positive effectiveness values that were statistically significant for KABC vs. 0 in both states and for KAB vs CO in New York. Furthermore, there is much consistency among the results from the three states, especially when the sample sizes are considered. It is emphasized that the child restraint effectiveness values obtained reflect the actual variety of makes and types of child restraints, as well as the actual patterns of misuse which characterize the samples. Therefore, the findings of this study most likely underestimate the effectiveness of child restraints in reducing the frequency and severity of injuries that would be found given the proper use of child restraints satisfying FMVSS 213.

3.0 ANALYSIS OF THE EFFECTIVENESS OF CHILD RESTRAINT SYSTEMS

In this section, the effectiveness of child restraint systems in reducing injuries is empirically assessed, using police-reported state mass accident data. Since existing state accident data files do not contain sufficient information for an *in-depth* evaluation of child restraint effectiveness,* the analyses necessarily focus on the use or non-use of child seating systems in general, regardless of whether or not they meet the requirements of FMVSS 213.

What follows is a brief description of CEM's approach to the analysis of child restraint effectiveness; a description of all relevant data bases used, along with information on how they were derived; a detailed presentation of the analysis; and finally, a summary of results.

3.1 Analysis Approach

The purpose of this analysis is twofold: (1) to test the hypothesis that the use of child restraint systems reduces the incidence of injuries sustained by children occupying accident-involved vehicles; and (2) to assess the magnitude of the percent reduction in injuries which can be attributed to child restraint usage.

To address the question of whether or not child restraint usage reduces the frequency or severity of child injuries, a comparison is made between the injury rates of children reported as using a child seating system with those of children who are unrestrained, after controlling for relevant accident characteristics. By inference, any obtained differences in these rates are attributed to the effect of the restraining device. Essentially, unrestrained children are treated as a control group.

Figure 3-1 depicts the basic Injury by Restraint Usage table central to the analyses, which is stratified by a set of control variables selected according to the procedures outlined in Section 3.3. Cell entries consist of both observed counts (n_{ijk}'s) and observed proportions (p_{ijk}'s).

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*For example, detailed and reliable information is not available at present on whether or not the child was in a restraint considered correct for his weight and size; whether the tether strap was fastened, if the restaint had one; whether the child restraint was anchored correctly by the vehicle's seat belt;or whether the child seating system was, in general, being misused. Furthermore, state accident coding forms do not at present differentiate among various types of child restraint systems.

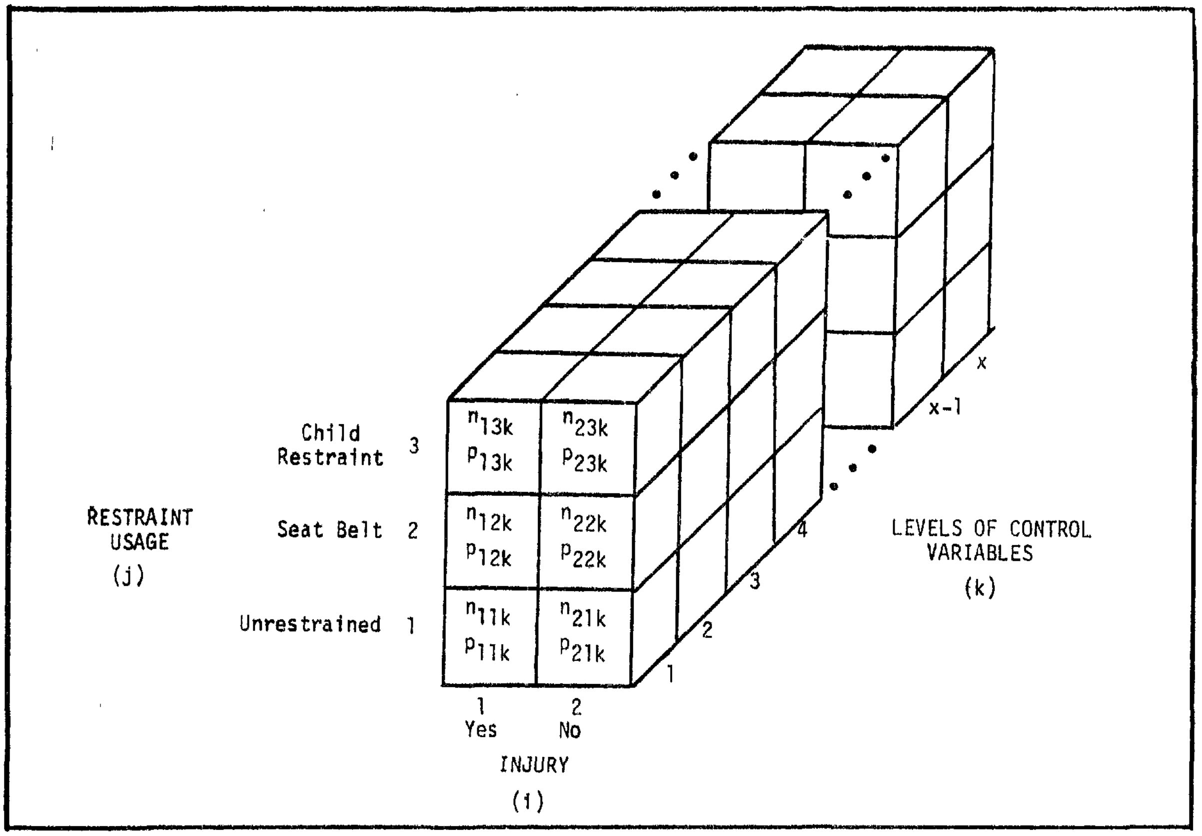

Figure 3-1. Basic Injury by Restraint Usage table, stratified by k-levels of control variables.

In general, effectiveness can be defined as follows:

$$E = \left[\frac{\text{Proportion of unrestrained children injured} - \text{Proportion of restrained children injured}}{\text{Proportion of unrestrained children injured}} \right] \times 100$$

However, estimates of effectiveness are computed separately for both child restraint and seat belt usage, so that the percent reduction in injuries due to the former can be compared to any corresponding reduction in injury associated with the latter. Using the notation presented in Figure 3-1, *overall* measures of effectiveness for child restraint and seat belt usage by children less than five years of age can be formulated as follows:

$$E_{(\text{Child Restraints})} = \left[1 - \frac{p_{13\bullet}}{p_{11\bullet}} \right] \times 100$$

$$E_{(\text{Seat Belts})} = \left[1 - \frac{p_{12\bullet}}{p_{11\bullet}} \right] \times 100$$

In addition to computing point estimates of effectiveness, an estimate of variability is necessary to generate the corresponding ranges of effectiveness (confidence intervals). Furthermore, in order to demonstrate that the observed effectiveness is significantly different from zero, one must reject the null hypothesis that there is no difference between the injury rates of restrained and unrestrained children.

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

- Selection of a set of relevant control variables.
- Smoothing of the data to remove chance variation.
- Adjustment of the data to allow for direct comparison of injury rates.

Each of these procedures is described in detail later in this section. In general, the effectiveness of child restraints is carried out in the following steps.

1. Select the full mass accident data base. The data bases analyzed are New York 1974 and 1977, New Jersey 1975, and Idaho 1976, 1977 and 1978.

2. Extract the partial data set to be used directly in evaluating child restraint effectiveness. The partial data set consists of occupants of passenger vehicles who were four years of age or younger.

3. Define a set of variables to be considered for modeling and adjustment purposes. In addition to Injury Level and Restraint Usage, all available variables that might represent possible confounding effects are considered for modeling and adjustment.

4. Apply the variable selection procedure. This procedure consists of ranking all potential variables according to the strength of their interactions with Injury and Restraint Usage, and choosing those variables with the highest overall degree of interaction.

5. Fit a hierarchical, log-linear model to the contingency table composed of Injury, Restraint Usage and those variables selected in Step 4. The purpose of modeling is to smooth the data and to remove random variability due to small cell frequencies that occur when a large number of control variables are used.

Modeling also reveals the strength of various interactions among the variables. For each year of New York data, separate models are fit for KA vs. BCO, KAB vs. CO and KABC vs. O injury dichotomies. For New Jersey, only the latter two models are fit, while in the case of Idaho, only one model for the KABC vs. O injury dichotomy is fit. This is a result of the smaller sample sizes for the latter two states.

6. Adjust the smoothed cell frequencies to allow for the direct comparison of injury rates. Adjustment is necessary in order to insure that the overall effectiveness estimates will not be affected by different distributions of children in child restraints, seat belts and unrestrained children across different levels of the control variables identified in Step 4.

7. Compute effectiveness and confidence intervals. The effectiveness of child restraints and seat belts is computed for each state-year of data,and an estimate made of the variances of these values. Appropriate confidence intervals are determined, and the hypothesis that differences in the injury rates of unrestrained and restrained children are significantly greater than zero is tested.

8. Extrapolate the results. A weighted mean of New York 1974 and 1977 values is used to extrapolate effectiveness to a nationwide basis.

3.2 Data Characteristics

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

- Relation of partial data set to full data base.
- Univariate frequency distribution of relevant variables.
- Injury rates for child restraint use, seat belt use and unrestrained by relevant variables.

In each case the data characteristics are discussed for four data sets:

- New York 1974
- New York 1977
- New Jersey 1975
- Idaho 1976-1978 (pooled).

The size of the partial data sets used in the analysis of child restraints relative to the entire state mass accident data bases can be characterized by noting the fraction of accidents, vehicles, injuries and fatalities contained in the full data set as given in Table 3-1. All results are based on analyses of the partial data sets derived from the above listed police-reported mass accident data bases.* CEM originally planned to also use NCSS data for 1976 and 1977. However, out of approximately 10,000 cases, about 50 children are coded as using child restraints, thus offering little opportunity for analysis.

As illustrated in Table 3-1, only a very small subset of each state's yearly accident data base was used for the analysis of the effectiveness of child restraints. Each partial data set was derived by selecting only those children between the ages of 0 and 4 (inclusive)** who could be fully cross-classified (i.e., had no missing information) with respect to injury severity, seating position, age and restraint usage. The resulting data set was further refined by eliminating children occupying vehicles other than passenger cars, as well as those children occupying seating positions other than front center, front right, back left, back center or back right - i.e., excluded were occupants of the far back seat in a station wagon, the driver's seat, etc. This was done because the number of fatalities for these children was disproportionately higher than for rear seat occupants. Since there were too few far back seat occupants to treat separately, their inclusion might have biased the findings. However, only five percent of the data was lost by eliminating occupants of the far back seat.

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*With the exception of Connecticut and Tennessee, no other states record the use or non-use of child restraining devices in their police accident reports to date.

**Children less than one year old could not be identified in either New Jersey or Idaho samples, since the particular code value used for infants was identical to that used for missing data.

TABLE 3-1

NUMBER OF ACCIDENTS, VEHICLES, INJURIES AND FATALITIES IN DATA BASES USED FOR THE ANALYSIS OF CHILD SEATING SYSTEMS

State*	Year	Variable	Full Data Base**	Partial Data Base+	Percent
New York	1974	Accidents Vehicles Injuries Fatalities	377,818 704,477 294,477 2,664	8,596 15,472 3,098 10	2.28 2.20 1.05 0.38
New York	1977	Accidents Vehicles Injuries Fatalities	355,683 662,175 281,119 2,471	8,873 15,971 3,054 12	2.49 2.41 1.09 0.49
New Jersey	1975	Accidents Vehicles Injuries Fatalities	219,526 409,207 103,537 1,079	5,548 9,762 2,083 16	2.53 2.39 2.01 1.48
Idaho	1976-1978 (Pooled)	Accidents Vehicles Injuries Fatalities	68,011 117,786 38,440 944	2,959 5,542 654 29	4.35 4.70 1.70 3.07

*For Idaho, the legal (dollar) reporting threshold was $100 in 1976, and $250 in both 1977 and 1978. For New Jersey, the legal reporting threshold was $200 in 1975. For New York, it was $200 in both 1974 and 1977.

**Reportable accidents only.

+Includes non-reportable accidents.

Basic characteristics of the samples derived from New York, New Jersey and Idaho police-reported accident data bases are contained in Appendix A, and are summarized only briefly in this section. Tables 3-2, 3-3 and 3-4 contain the univariate frequencies of certain "key" variables used in the analysis of child restraints for the New York 1974 (N=10,745), New York 1977 (N=11,092), New Jersey (N=6738) and Idaho (pooled N=3766) samples. From these tables, it can be seen that:

- *Overall* injury rates (K+A+B+C) are higher for children in New Jersey (31 percent) and New York (28 percent), as compared to Idaho (18 percent). The majority of children, however, sustained no injuries (between 69 and 82 percent).

TABLE 3-2

FREQUENCY DISTRIBUTIONS OF KEY VARIABLES FROM NEW YORK 1974 AND 1977 SAMPLES

Variable	Category	1974		1977	
		Absolute Frequency	% of Known	Absolute Frequency	% of Known
Child's Injury Level	None	7647	71.2	8038	72.5
	C	1117	10.4	1191	10.7
	B	1635	15.2	1612	14.5
	A	293	2.7	239	2.2
	K	10	0.1	12	0.1
	Injured (Extent Unknown)	43	0.4	--	--
Restraint Usage	None	8542	79.5	8768	79.2
	Seatbelt	1411	13.1	1327	12.0
	Child Seat	792	7.4	979	8.8
Sex of Child	Male	5558	52.0	5677	51.3
	Female	5128	48.0	5383	48.7
	Missing	59	--	32	--
Age of Child	Less than Two Years	2695	25.1	3262	29.4
	Two Years	2537	23.6	2663	24.0
	Three Years	2798	26.0	2623	23.6
	Four Years	2715	25.3	2544	22.9
Child's Seating Position	Front Center	2730	25.4	2817	25.4
	Front Right	2565	23.9	2741	24.7
	Back Left	1808	16.8	1785	16.1
	Back Center	1666	15.5	1802	16.2
	Back Right	1976	18.4	1947	17.6
Sex of Driver	Male	4955	46.1	5200	46.9
	Female	5790	53.9	5892	53.1
Age of Driver	16-25	2824	26.5	2786	25.3
	26-30	3345	31.4	3526	32.0
	30 or Older	4471	42.0	4712	42.7
	Missing	105	--	68	--
Number of Vehicles in Accident	One	1442	13.4	1473	13.3
	Two	8067	75.1	8168	73.6
	Three or More	1236	11.5	1451	13.1
Road Classification	State Highway	3780	36.7	4302	40.2
	County Road	1394	13.5	1428	13.4
	Town Road	1368	13.3	1417	13.2
	City Street	3009	29.2	2700	25.2
	Limited Access	749	7.3	851	8.0
	Missing	445	--	394	--
Road Surface Condition	Dry	7098	66.2	6781	61.3
	Wet	2557	23.9	2589	23.4
	Muddy	8	0.1	14	0.1
	Snow/Ice	863	8.1	1505	13.6
	Slush	146	1.4	148	1.3
	Other	27	0.3	24	0.2
	Missing	26	--	31	--

TABLE 3-2 (Continued)

Variable	Category	1974		1977	
		Absolute Frequency	% of Known	Absolute Frequency	% of Known
Weather Condition	Clear	7416	69.4	7218	65.3
	Cloudy	1675	15.7	1933	17.5
	Rain	239	2.2	272	2.5
	Snow	612	5.7	667	6.0
	Sleet/Hail	665	6.2	880	8.0
	Fog/Smog/Smoke	85	0.8	83	0.8
	Missing	53	--	39	--
Vehicle Weight	LT 3000 lbs	2701	27.8	Not Available*	
	3000 - 3599 lbs	2553	26.2		
	3600-4399 lbs	3531	36.3		
	4400 lbs or More	939	9.6		
	Missing	1012	--		
Towaway	No	7423	69.1	Not Available	
	Yes	3322	30.9		
Extent of Vehicle Damage	None	498	4.7	Not Available	
	Light	3036	28.8		
	Moderate	5629	53.4		
	Severe	1291	12.2		
	Demolished	94	0.9		
	Missing	197	--		
Initial Point of Impact	Front	3308	32.1	Not Available	
	Right Side	2713	26.3		
	Left Side	2737	26.6		
	Rear	1547	15.0		
	Missing	440	--		
Total Number of Cases		10,745	--	11,092	--

*This information was not coded in New York for 1977.

TABLE 3-3

FREQUENCY DISTRIBUTIONS OF KEY VARIABLES FROM NEW JERSEY 1975 SAMPLE

Variable	Category	Absolute Frequency	% of Known
Child's Injury Level	None	4652	69.0
	Type C	1342	19.6
	Type B	707	10.5
	Type A	52	0.8
	Killed	3	0.0
Restraint Usage	None	5174	76.8
	Seatbelt	931	13.8
	Child Restraint	633	9.4
Sex of Child	Male	3470	51.8
	Female	3232	48.2
	Missing	36	--
Age of Child	One Year	1737	25.8
	Two Years	1566	23.2
	Three Years	1711	25.4
	Four Years	1724	25.6
Child's Seating Position	Front Center	1788	26.5
	Front Right	1815	26.9
	Back Left	1380	20.5
	Back Center	883	13.1
	Back Right	872	12.9
Sex of Driver	Male	2663	39.1
	Female	4066	60.4
	Missing	9	--
Age of Driver	15-25	1937	28.8
	26-30	2079	30.9
	31-54	2469	36.8
	55 or Older	233	3.5
	Missing	20	--
Number of Vehicles in Accident	One	791	11.7
	Two or More	5947	88.3
Severity of Accident	No Injury other than Child's	3236	48.0
	Injury or Fatality	3502	52.0
City Size	LT 5,000	637	9.5
	5,000- 24,999	3019	44.8
	25,000-49,999	1667	24.7
	50,000-99,999	814	12.1
	100,000 or More	601	8.9
Road Classification	State Highway	2223	33.0
	County Road	2583	38.3
	City Street	1737	25.8
	Interstate	195	2.9
Weather	Clear/Cloudy	4907	73.0
	Rain	1553	23.1
	Snow	193	2.9
	Fog	25	0.4
	Other	48	0.7
	Missing	12	--
Road Surface Condition	Dry	4580	68.2
	Wet	1840	27.4
	Snow/Ice	280	4.1
	Other	19	4.1
	Missing	19	--
Traffic Density	Light	2432	36.2
	Medium	3155	47.0
	Heavy	1126	16.8
	Missing	25	--
Total Number of Cases		6738	--

TABLE 3-4

FREQUENCY DISTRIBUTIONS OF KEY VARIABLES FROM IDAHO 1976/1977/1978 SAMPLE

Variable	Category	Absolute Frequency	% of Known
Child's Injury Level	None	3105	82.4
	Type C	213	5.7
	Type B	368	9.8
	Type A	73	1.9
	Killed	7	0.2
Restraint Usage	None	3289	87.3
	Seatbelt	332	8.8
	Child Restraint	145	3.9
Sex of Child	Male	1890	50.3
	Female	1865	49.7
	Missing	11	--
Age of Child	One Year	1111	29.5
	Two Years	1009	26.8
	Three Years	851	22.6
	Four Years	795	21.1
Child's Seating Position	Front Center	1021	27.1
	Front Right	1265	33.6
	Back Left	487	12.6
	Back Center	536	14.2
	Back Right	457	12.1
Sex of Driver	Male	1299	35.3
	Female	2386	64.7
	Missing	81	--
Age of Driver	16-25	1443	39.1
	26-30	1183	32.0
	31-54	937	25.4
	55 or Older	131	3.5
	Missing	72	--
Number of Vehicles in Accident	One	478	12.7
	Two	3288	87.3
Severity of Accident	No Injury other than Child's	2427	64.4
	Injury or Fatality	1339	35.6
Rural/Urban	Rural	1452	38.6
	Urban	2314	61.4
Initial Point of Impact	Front	1425	39.8
	Side	1661	46.4
	Rear	495	13.8
	Missing	185	--
Was Vehicle Totalled?	No	2593	85.0
	Yes	458	15.0
	Missing	715	--
Extent of Vehicle Damage	$250 or Less	1235	34.6
	$251-$500	1179	33.0
	$501-$1000	702	19.7
	$1001 or More	456	12.7
	Missing	194	--
Total Number of Cases		3766	--

- The percentage of children suffering either serious or fatal injuries (K+A) in New York and Idaho is 2.5 to 3 times greater than in New Jersey (2.5 and 2.1 vs 0.84 percent, respectively), although the overall incidence of serious and fatal injuries is quite small in all states.

- In New Jersey, 76.8 percent of children in accidents were unrestrained, compared to 87.3 percent in Idaho and 79.3 percent in New York. However, the rate of child restraint usage in New Jersey and New York is more than twice that found in Idaho (9.4 and 8.2 percent vs. 3.8 percent), while the seat belt usage rate for children in New Jersey and New York is approximately 1.5 times greater than in Idaho (13.8 and 12.5 percent vs. 8.8 percent).

- Children (1-4 years old) in accidents in each sample are essentially uniformly distributed by age, although in New York 1977, the inclusion of infants in the one-year-old category increases the frequency of one year old children who are involved in accidents. The greater number of one year old children in Idaho might possibly reflect the inclusion of infants in the sample due to police reporting errors with respect to their age.

- In Idaho, 60.7 percent of children ride in the front seat, with slightly more than half of these occupying the front center seat. In New Jersey, only 53.5 percent of the children ride in the front seat, with equal frequency of front right and front center seat occupancy. In New York, about 50 percent of the children occupy front seats, with little difference in frequency of front right and front center occupancy.

- In each state, male children are involved in accidents slightly more frequently than female children.

- The ratio of single-vehicle accidents to multivehicle accidents is roughly the same in each state.

In addition to the foregoing sample characteristics, Appendix A contains a summary of selected *bivariate* relationships between key variables in New York, New Jersey and Idaho samples.

3.3 Variable Selection

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

1. For each potential variable, a three variable saturated log-linear model containing Injury, Restraint Usage and Variable is fit.

2. Three likelihood ratio (LR) chi-square (χ^2) statistics are computed for the differences between the saturated model and three separate sub-models, the first of which differs from the saturated model only by the exclusion of the Variable x Injury interaction term,

the second differing only by the exclusion of the Variable x Restraint Usage interaction term, and the third differing only by the exclusion of the Variable x Injury x Restraint Usage interaction term.

3. The harmonic mean of the three $LR\chi^2$ statistics is computed.

4. The variables are ordered according to the magnitude of the harmonic mean, and the highest ranked variables are selected for modeling and adjustment.

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

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

Figure 3-2 illustrates a typical example of the effort involved in determining the "optimal" cutting points of the variable city size in the New Jersey 1975 sample. (The 25,000 cutting point is chosen.)

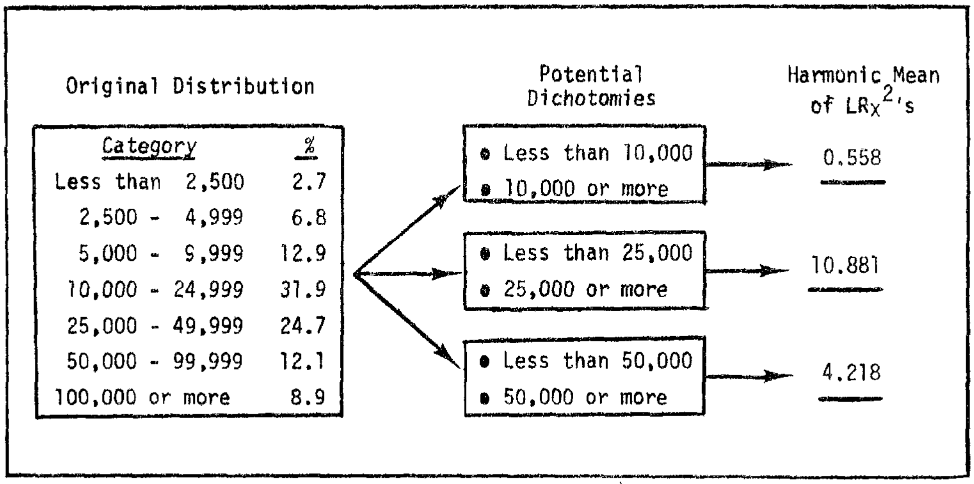

Figure 3-2. Example of determination of "optimal" cutting points of categorical variables.

Tables 3-2, 3-3 and 3-4 contain the variables which were candidates for selection in the New York, New Jersey and Idaho samples. Injury rates (KABC percentages), along with the number of child occupants in each restraint category, are presented separately for each variable category in Tables 3-5 through 3-8 for New York 1974, New York 1977, New Jersey and Idaho.

It was noted previously that the overall injury rates for New York, New Jersey and Idaho are 28 percent, 31 percent and 18 percent respectively. The figures can be kept in mind in the brief discussions below. In the New York 1974 sample, injury rates range from a high of 47.0 percent for unrestrained children in severely damaged vehicles to a low of 10.0 percent for children in child restraints in cars experiencing no damage or only light damage. As might be anticipated, rates are higher for towaway accidents, severely damaged vehicles, vehicles weighing less than 3000 lbs., children in front seats, vehicles experiencing frontal impacts and roads classified as limited access and city streets. The injury rates for the New York 1977 sample are generally similar. Considering the question of restraint usage, the overall injury rates are 19.8 percent for children using child restraints, 22.3 percent for children using seat belts and 30.7 percent for unrestrained children in New York 1974. The corresponding values for New York 1977 are 21.1 percent, 18.6 percent and 29.6 percent, respectively.

In New Jersey, injury rates range from a high of 48.0 percent for unrestrained children in accidents involving injury or fatality to a low of 8.3 percent for children in seat belts in accidents in which there was no injury other than the child (if the child had an injury). Injury rates are higher for unrestrained child front seat occupants, Interstate highways, vehicles with young drivers (16-25 years old) and accidents with injuries or fatalities. Overall, the injury rates are 27.0 percent for children in child restraints, 17.7 percent for children using seat belts and 33.8 percent for unrestrained children.

In Idaho, injury rates range from 47.4 percent for children in child restraints in "totalled" vehicles (only 31 children in this category) to 0.0 percent for children in seat belts in vehicles suffering a rear impact (43 children in this category). Injury rates are higher for totalled vehicles, single vehicle accidents, accidents involving an injury or fatality and accidents in which the vehicle damage was greater than $500. Overall, the injury rates are 15.9 percent for children in child restraints, 10.5 percent for children using seat belts and 18.3 percent for unrestrained children.

TABLE 3-5
INJURY RATES FOR NEW YORK 1974 SAMPLE

Variable	Category	Injury Rate (Percent)			Number of Child Occupants			
		Child Restraints	Seatbelts	Unrestrained	Child Restraints	Seatbelts	Unrestrained	Total
Road Classification (N = 10,300)	State Highway	19.1	18.2	28.1	335	506	2939	3780
	County/Town Road	19.5	18.0	29.2	226	383	2153	2762
	City Street	26.3	33.0	37.0	152	339	2518	3009
	Limited Access	17.0	30.4	30.3	47	125	577	749
Age of Child (N = 10,745)	One Year	19.0	18.6	27.4	485	371	1837	2695
	Two Years	22.7	17.9	32.0	185	324	2028	2537
	Three Years	18.8	26.1	29.5	85	364	2349	2798
	Four Years	18.9	26.4	33.5	37	352	2326	2715
Vehicle Weight (N = 9,733)	LT 3000 lbs	24.3	28.3	34.6	222	396	2092	2710
	3000-3599 lbs	20.0	17.7	29.7	205	294	2054	2553
	3600 lbs or More	16.6	21.5	27.9	314	591	3565	4470
Extent of Vehicle Damage (N = 10,548)	None/Light	10.0	14.6	22.2	260	460	2814	3534
	Moderate	19.1	22.9	32.1	414	767	4448	5629
	Severe	45.3	39.1	47.0	106	161	1118	1385
Initial Point of Impact (N = 10,305)	Front	23.4	27.2	35.5	214	390	2704	3308
	Side	19.9	19.8	29.2	412	739	4299	5450
	Rear	11.7	20.0	23.5	128	240	1179	1547
Towaway (N = 10,745)	Yes	33.7	33.6	42.4	243	393	2686	3322
	No	13.7	18.0	25.4	549	1018	5856	7423
Number of Vehicles in Accident (N = 10,745)	One	27.8	24.1	34.3	97	166	1179	1442
	Two	18.4	21.9	30.3	610	1056	6401	8067
	Three or More	21.2	23.3	29.5	85	189	962	1236
Sex of Driver (N = 10,745)	Male	16.4	23.5	31.7	269	613	4073	4955
	Female	21.6	21.4	29.9	523	798	4469	5790
Age of Driver (N = 10,640)	16-25	22.5	24.8	32.4	222	318	2284	2824
	26-30	19.0	20.0	29.9	315	491	2539	3345
	31 or Older	17.7	22.7	30.2	243	596	3632	4471
Child's Seating Position (N = 10,745)	Front Seat	22.2	24.8	35.4	374	689	4232	5295
	Back Seat	17.7	19.9	26.1	418	722	4310	5450
Sex of Child (N = 10,686)	Male	18.7	22.6	30.6	407	707	4444	5558
	Female	21.1	22.4	31.1	383	693	4052	5128
Weather (N = 10,742)	Clear/Cloudy	19.7	22.5	30.5	588	1059	6605	8252
	Other	20.2	21.9	31.6	203	347	1922	2472
Road Surface Condition (N = 10,719)	Dry	19.7	22.7	30.7	527	935	5636	7098
	Other	20.1	21.5	30.9	264	474	2883	3621

TABLE 3-6

INJURY RATES FOR NEW YORK 1977 SAMPLE

Variable	Category	Injury Rate (Percent)			Number of Child Occupants			
		Child Restraints	Seatbelts	Unrestrained	Child Restraints	Seatbelts	Unrestrained	Total
Road Classification (N = 10,698)	State Highway	18.8	14.3	26.2	383	510	3409	4302
	County/Town Road	23.9	16.4	31.4	306	384	2155	2845
	City Street	20.9	28.8	34.6	187	267	2246	2700
	Limited Access	22.5	23.4	29.1	71	124	656	851
Vehicle Weight (N = 10,080)	LT 3000 lbs	20.6	23.0	34.3	291	326	2026	2643
	3000-3599 lbs	19.8	17.5	30.0	248	309	1976	2533
	3000 lbs or More	21.7	15.9	26.4	378	579	3947	4904
Age of Driver (N = 11,024)	16-25	26.2	22.3	31.9	244	247	2295	2786
	26-30	22.0	17.6	29.1	386	467	2673	3526
	31 or Older	16.9	17.8	28.3	344	602	3766	4712
Age of Child (N = 11,092)	One Year	20.2	16.8	28.2	667	434	2161	3262
	Two Years	23.3	16.9	30.9	210	314	2139	2663
	Three Years	25.8	20.8	29.1	62	303	2258	2623
	Four Years	17.5	21.0	30.2	40	276	2228	2544
Number of Vehicles in Accident (N = 11,092)	One	23.0	21.0	34.0	113	167	1193	1473
	Two	21.7	18.1	28.8	738	951	6479	8168
	Three or More	16.4	19.1	29.4	128	209	1114	1451
Child's Seating Position (N = 11,092)	Front Seat	24.4	20.8	34.0	430	638	4490	5558
	Back Seat	18.6	16.5	25.0	549	689	4296	5534
Road Surface Condition (N = 11,061)	Dry	22.7	18.8	29.9	578	818	5385	6781
	Other	19.1	18.2	29.1	397	506	3377	4280
Sex of Child (N = 11,061)	Male	20.8	19.2	30.1	523	657	4497	5677
	Female	21.1	18.2	29.2	451	664	4268	5383
Sex of Driver (N = 11,092)	Male	18.6	19.8	29.4	317	576	4307	5200
	Female	22.4	17.7	29.8	662	751	4479	5892
Weather (N = 11,071)	Clear/Cloudy	21.6	18.4	29.6	712	988	6593	8293
	Other	19.9	19.0	29.5	266	336	2176	2778

TABLE 3-7

INJURY RATES FOR NEW JERSEY 1975 SAMPLE

Variable	Category	Injury Rate (Percent)			Number of Child Occupants			
		Child Restraints	Seatbelts	Unrestrained	Child Restraints	Seatbelts	Unrestrained	Total
Child's Seat Position (N = 6,738)	Front Seat	26.7	20.1	40.4	326	536	2,741	3,603
	Back Seat	27.4	14.4	26.4	307	395	2,433	3,135
Road Classification (N - 6,738)	State Highway	26.7	20.7	30.5	221	328	1,674	2,223
	County Road	29.9	13.4	33.9	231	374	1,978	2,583
	City Street	22.4	19.5	37.2	161	200	1,376	1,737
	Interstate	35.0	27.6	39.7	20	29	146	195
City Size (N = 6,738)	LT 25,000	26.4	13.0	30.4	383	507	2,766	3,656
	25,000 or More	28.0	23.3	37.8	250	424	2,408	3,082
Age of Driver (N = 6,714)	16 - 25	27.7	21.6	37.3	166	222	1,549	1,937
	26 - 30	27.8	14.9	34.6	237	328	1,514	2,079
	31 or older	25.7	17.8	30.3	230	381	2,091	2,702
Age of Child (N = 6,738)	One Year	28.0	16.4	35.9	400	238	1,099	1,737
	Two Years	28.5	17.9	34.2	158	240	1,168	1,566
	Three Years	17.0	20.2	31.5	47	218	1,446	1,711
	Four Years	21.4	16.6	34.2	28	235	1,461	1,724
Severity of Accident (N - 6,738)	No Injury other than Child's	10.7	8.3	17.5	281	555	2,400	3,236
	Injury or Fatality	40.1	31.6	48.0	352	376	2,774	3,502
Traffic Density (N = 6,713)	Light	26.7	19.3	36.9	210	296	1,926	2,432
	Medium/Heavy	27.2	17.0	31.8	423	631	3,227	4,281
Sex of Child (N = 6,702)	Male	27.1	15.5	32.4	321	517	2,632	3,470
	Female	26.8	20.4	35.4	302	412	2,518	3,232
Sex of Driver (N = 6,729)	Male	27.4	20.5	35.6	164	375	2,124	2,663
	Female	26.7	15.9	32.5	468	555	3,043	4,066
Number of Vehicles in Accident (N = 6,738)	One	24.1	19.0	39.0	83	105	603	791
	Two	27.5	17.6	33.1	550	826	4,571	5,947
Weather (N = 6,726)	Clear/Cloudy	27.4	18.5	34.2	470	642	3,795	4,907
	Other	25.9	16.0	32.6	162	287	1,370	1,819
Road Surface Condition (N = 6,719)	Dry	27.7	18.6	34.6	441	587	3,552	4,580
	Other	25.1	16.2	32.0	191	340	1,608	2,139

TABLE 3-8

INJURY RATES FOR IDAHO 1976/1977/1978 SAMPLE

Variable	Category	Injury Rate (Percent)			Number of Child Occupants			
		Child Restraints	Seatbelts	Unrestrained	Child Restraints	Seatbelts	Unrestrained	Total
Age of Driver (N = 3,694)	16-25	19.0	10.1	21.8	58	109	1,276	1,443
	26-30	8.8	11.5	17.2	57	122	1,004	1,183
	31 or older	25.9	10.0	15.3	27	100	941	1,068
Age of Child (N = 3,766)	One Year	15.8	12.9	18.3	95	124	892	1,111
	Two Years	22.6	8.6	16.2	31	93	885	1,009
	Three Years	7.7	8.2	19.9	13	61	777	851
	Four Years	0.0	11.1	19.3	6	54	735	795
Extent of Vehicle Damage (N = 3,572)	$500 or Less	7.1	4.0	11.3	84	226	2,104	2,414
	$501 or More	32.1	25.8	31.5	53	97	1,008	1,158
Initial Point of Impact (N = 3,581)	Front	24.1	11.6	23.2	58	121	1,246	1,425
	Side	13.6	10.7	16.6	59	159	1,443	1,661
	Rear	4.3	0.0	7.0	23	43	429	495
Severity of Accident (N = 3,766)	No Injury Other than Child's	3.4	4.3	8.6	88	233	2,106	2,427
	Injury or Fatality	35.1	25.3	35.6	57	99	1,183	1,339
Rural/Urban (N = 3,766)	Rural	14.9	16.3	20.1	47	123	1,282	1,452
	Urban	16.3	7.2	17.2	98	209	2,007	2,314
Sex of Child (N = 3,755)	Male	17.2	11.1	17.0	87	171	1,632	1,890
	Female	13.8	9.4	19.7	58	160	1,647	1,865
Number of Vehicles in Accident (N = 3,766)	One	15.8	26.5	31.8	19	34	425	478
	Two	15.9	8.7	16.3	126	298	2,864	3,288
Sex of Driver (N = 3,685)	Male	20.0	8.5	16.6	30	106	1,163	1,299
	Female	15.3	11.3	19.2	111	221	2,054	2,386
Was Vehicle Totalled? (N = 3,051)	No	10.6	7.6	13.2	94	238	2,261	2,593
	Yes	47.4	41.9	44.4	19	31	408	458
Child's Seat Position (N = 3,766)	Front	20.5	11.9	21.6	78	202	2,006	2,28[illegible]
	Back	10.4	8.5	13.3	67	130	1,283	1,480

The information used in the variable selection procedure to determine those variables selected for modeling and adjustment purposes in the New York 1974, New York 1977, New Jersey and Idaho samples is given in Tables 3-9, 3-10, 3-11 and 3-12. In each table, the variables analyzed are listed in descending order of the magnitude of the harmonic mean of the $LR\chi^2$'s of the partial association of the following three interaction terms: Variable x Injury, Variable x Restraint Usage, and Variable x Injury x Restraint Usage. For the convenience of the reader, the variables selected in each sample are listed below in the same order as they appear in the tables.

New York 1974

Road Classification
Age of Child
Vehicle Weight
Extent of Vehicle Damage

New York 1977

Road Classification
Vehicle Weight
Age of Driver

New Jersey 1975

Child's Seat Position
Road Classification
City Size
Age of Driver

Idaho (1976-1978)

Age of Driver
Age of Child
Extent of Vehicle Damage

Thus, the most frequently used variables for modeling and adjustment are Road Classification, Age of Driver, Age of Child, Vehicle Weight and Extent of Vehicle Damage.

TABLE 3-9

INTERACTION TERMS EVALUATED IN VARIABLE SELECTION PROCEDURE

NEW YORK 1974 SAMPLE

Variable	Interaction Terms from the 3-Variable Saturated Model Containing Injury, Restraint Usage and Variable						Harmonic Mean of Interaction Terms
	Variable x Injury		Variable x Restraint Usage		Variable x Injury x Restraint Usage		
	LR x^2	df	LR x^2	df	LR x^2	df	
Road Classification	81.67	3	54.98	6	12.02*	6	26.40
Age of Child	25.17	3	636.38	6	10.78*	6	22.38
Vehicle Weight	39.72	2	18.62	4	4.86*	4	10.54
Extent of Vehicle Damage	317.69	2	4.90*	4	10.46	4	9.91
Initial Point of Impact	75.05	2	15.48	4	4.06*	4	9.25
Towaway	318.80	1	3.41*	2	4.38*	2	5.72
Number of Vehicles in Accident	10.51	2	9.00*	4	2.61*	4	5.09
Sex of Driver	2.47*	1	58.50	2	4.85*	2	4.78
Age of Driver	7.14	2	63.50	4	1.79*	4	4.20
Child's Seat Position	92.72	1	0.45*	2	1.90*	2	1.09
Sex of Child	0.41*	1	1.78*	2	0.62*	2	0.65
Weather	0.59*	1	6.58	2	0.28*	2	0.55
Road Surface Condition	0.01*	1	0.08*	2	0.29*	2	0.26

*p >0.05

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

TABLE 3-10

INTERACTION TERMS EVALUATED IN VARIABLE SELECTION PROCEDURE
NEW YORK 1977 SAMPLE

Variable	Interaction Terms from the 3-Variable Saturated Model Containing Injury, Restraint Usage and Variable						Harmonic Mean of Interaction Terms
	Variable x Injury		Variable x Restraint Usage		Variable x Injury x Restraint Usage		
	LR x^2	df	LR x^2	df	LR x^2	df	
Road Classification	62.31	3	49.86	6	14.31	6	28.31
Vehicle Weight	42.13	2	30.76	4	5.86*	4	13.22
Age of Driver	15.23	2	67.64	4	4.41*	4	9.77
Age of Child	5.61*	3	881.09	6	4.62*	6	7.58
Number of Vehicles in Accident	13.43	2	11.36	4	2.52*	4	5.36
Child's Seat Position	94.86	1	14.83	2	1.29*	2	3.52
Road Surface Condition	1.45*	1	1.80*	2	1.07*	2	1.38
Sex of Child	0.72*	1	3.51*	2	0.37*	2	0.69
Sex of Driver	0.18*	1	107.63	2	2.73*	2	0.51
Weather	0.05*	1	2.61*	2	0.38*	2	0.13

*$p > 0.05$

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

TABLE 3-11

INTERACTION TERMS EVALUATED IN VARIABLE SELECTION PROCEDURE NEW JERSEY 1975 SAMPLE

Variable	Interaction Terms from the 3-Variable Saturated Model Containing Injury, Restraint Usage and Variable						Harmonic Mean of Interaction Terms
	Variable x Injury		Variable x Restraint Usage		Variable x Injury x Restraint Usage		
	LR x^2	df	LR x^2	df	LR x^2	df	
Child's Seat Position	105.30	1	15.12	2	13.20	2	19.82
Road Classification	13.86	3	10.86*	6	16.59	6	13.36
City Size	42.15	1	10.02	2	6.57	2	10.88
Age of Driver	19.84	2	30.77	4	4.67*	4	10.10
Age of Child	4.91*	3	604.66	6	5.69*	6	7.87
Severity of Accident	712.68	1	27.68	2	1.69*	2	4.77
Traffic Density	12.98	1	10.06	2	1.67*	2	3.87
Sex of Child	6.86	1	4.98*	2	2.03*	2	3.58
Sex of Driver	7.30	1	55.87	2	1.28*	2	3.20
Number of Vehicles in Accident	6.01	1	1.39*	2	2.47*	2	2.32
Weather	1.81*	1	7.26	2	0.28*	2	0.70
Road Surface Condition	4.43	1	10.01	2	0.08*	2	0.23

*$P > 0.05$

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

TABLE 3-12

INTERACTION TERMS EVALUATED IN VARIABLE SELECTION PROCEDURE
IDAHO 1976/1977/1978 SAMPLE

Variable	Interaction Terms from the 3-Variable Saturated Model Containing Injury, Restraint Usage and Variable						Harmonic Mean of Interaction Terms
	Variable x Injury		Variable x Restraint Usage		Variable x Injury x Restraint Usage		
	LR X^2	df	LR X^2	df	LR X^2	df	
Age of Driver	15.24	2	14.36	4	6.13*	4	10.06
Age of Child	3.76*	3	117.25	6	6.21*	6	6.89
Extent of Vehicle Damage	219.24	1	2.76*	2	5.16*	2	5.35
Initial Point of Impact	77.94	2	2.26*	4	4.30*	4	4.36
Severity of Accident	407.68	1	2.68*	2	2.88*	2	4.15
Rural/Urban	6.71	1	2.67*	2	4.32*	2	3.97
Sex of Child	2.92*	1	5.91*	2	1.76*	2	2.78
Number of Vehicles in Accident	56.92	1	1.01*	2	2.96*	2	2.23
Sex of Driver	3.51*	1	15.78	2	0.98*	2	2.19
Was Vehicle Totalled?	221.44	1	1.27*	2	1.65*	2	2.15
Child's Seat Position	40.93	1	2.90*	2	0.48*	2	1.22

*$p > 0.05$

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

3.4 Analysis of Mass Accident Data

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

3.4.1 Modeling

The basic purpose of modeling as it is applied to the evaluation of child restraint effectiveness is twofold:

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

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

The fitting of log-linear models to the data involves several steps. First, fully cross-classified contingency tables--i.e.,containing no missing data for any of the variables--were constructed, using Injury Level, Restraint Usage and all variables selected by the procedure discussed in Section 3.3. Depending upon the size of a given sample, tables were generated using several different injury dichotomies, as follows.

- For New York 1974 and 1977 samples, three tables were constructed for each sample for KA vs. BCO, KAB vs CO and KABC vs O injury dichotomies.
- For the New Jersey 1975 sample, two tables were generated, for KAB vs. CO and KABC vs. O injury dichotomies.
- For the Idaho 1976-1978 sample, only one table was constructed, for the KABC vs. O injury dichotomy.

Appendix B contains complete listings of each of the above nine contingency tables.

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

1. As many significant effects as required were first specified in an attempt to derive a model with an optimal fit. Optimal fit refers to the situation in which the magnitude of the model's LR chi-square is roughly similar to its number of degrees of freedom.

2. Effects were either deleted or added to the model in a stepwise fashion until the deletion of any one effect would result in a significant worsening of the fit, whereas the addition of any single effect would not significantly improve the model's fit.

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

Tables 3-13 to 3-16 summarize the models fit to data for the various samples and injury dichotomies used. The likelihood ratio (LR) chi-square values were derived from tests of marginal association for each effect, in which the cell counts for the complete contingency table were summed over all unspecified margins, after which the effect (interaction term) was tested to be zero, using a LR Chi-square statistic.

Since the log-linear models fitted are hierarchical models, the specification of a given effect forces all lower-order effects which are subsets of the effect into the model. For example, if an "Injury x Restraint Usage x Child Age" effect is specified, the following additional terms are hierarchically included:

- Injury x Restraint Usage
- Injury x Child Age
- Restraint Usage x Child Age
- Injury
- Restraint Usage
- Child Age

---

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

TABLE 3-13

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

Effect	KA vs. BCO			KAB vs. CO			KABC vs. 0		
	LR_X2	df	Prob.	LR_X2	df	Prob.	LR_X2	df	Prob.
Injury x Rd. Class	--	--	--	22.22	3	0.0001	--	--	--
Injury x Child Age	--	--	--	12.69	3	0.0054	38.12	3	0.0000
Injury x Weight	--	--	--	37.95	2	0.0000	39.16	2	0.0000
Injury x Damagw	65.49	2	0.0000	--	--	--	--	--	--
Restraint x Rd.Class	--	6	--	49.75	6	0.0000	47.70	6	0.0000
Restraint x Child Age	570.39	6	0.0000	570.39	6	0.0000	574.69	6	0.0000
Restraint x Weight	13.55	4	0.0089	13.55	4	0.0089	14.49	4	0.0059
Rd. Class x Child Age	--	--	--	--	--	--	9.76	9	0.3701
Child Age x Weight	21.64	6	0.0014	21.64	6	0.0014	22.54	6	0.0015
Injury x Restraint x Rd. Class	17.25	6	0.0084	--	--	--	--	--	--
Injury x Restraint x Damage	--	--	--	13.85	4	0.0078	10.51	4	0.0327
Injury x Rd.Class x Damage	--	--	--	--	--	--	15.49	6	0.0168
Rd.Class x Weight x Damage	21.21	12	0.0474	21.21	12	0.0474	22.65	12	0.0309
Summary of Model	641.42	787	1.000	780.99	780	0.4833	734.55	765	0.7799

TABLE 3-14

SUMMARY OF TESTS OF MARGINAL ASSOCIATION OF DIRECTLY SPECIFIED MODEL EFFECTS FOR NEW YORK 1977 SAMPLE

Effect	KA vs. BCO			KAB vs. CO			KABC vs. 0		
	LR_X2	df	Prob.	LR_X2	df	Prob.	LR_X2	df	Prob.
Injury x Restraint	15.76	2	0.0004	--	--	--	--	--	--
Injury x Weight	6.83	2	0.0329	--	--	--	33.78	2	0.0000
Injury x Dr.Age	9.85	2	0.0073	19.04	2	0.0001	16.23	2	0.0003
Restraint x Rd.Class	39.43	6	0.0000	--	--	--	--	--	--
Restraint x Weight	28.15	4	0.0000	--	--	--	28.15	4	0.0000
Restraint x Dr.Age	65.56	4	0.0000	65.56	4	0.0000	65.56	4	0.0000
Injury x Restraint x Rd. Class	--	--	--	--	--	--	14.44	6	0.0251
Rd. Class x Weight x Dr.Age	23.51	12	0.0237	23.51	12	0.0237	23.51	12	0.0237
Injury x Restraint x Rd. Class x Weight	--	--	--	20.32	12	0.0613	--	--	--
Summary of Model	151.73	157	0.6039	129.51	114	0.1519	149.46	148	0.4509

TABLE 3-15

SUMMARY OF TESTS OF MARGINAL ASSOCIATION OF DIRECTLY SPECIFIED MODEL EFFECTS FOR NEW JERSEY 1975 SAMPLE

Effect	Injury Dichotomy					
	KAB vs. CO			KAB vs. O		
	LR χ^2	df	Prob.	LR χ^2	df	Prob.
Injury x Dr. Age	--	--	--	22.43	2	0.0000
Injury x Restraint x Seat Pos.	11.14	2	0.0038	--	--	--
Injury x Restraint x Rd. Class	15.90	4	0.0032	16.23	4	0.0027
Injury x Seat Pos. x Rd. Class	--	--	--	12.72	2	0.0017
Seat Pos. x Rd. Class x Dr.Age	--	--	--	12.97	4	0.0114
Injury x Restraint x Seat Pos. x City Size	--	--	--	6.17	2	0.0457
Restraint x Seat Pos. x City Size x Dr.Age	13.04	4	0.0111	13.04	4	0.0111
Restraint x Rd.Class x City Size x Dr.Age	21.27	8	0.0065	21.27	8	0.0065
Injury x Seat Pos. x Rd. Class x City Size x Dr.Age	12.01	4	0.0172	--	--	--
Summary of Model	99.95	88 of 215	0.1808	121.36	116 of 215	0.3482

TABLE 3-16

SUMMARY OF TESTS OF MARGINAL ASSOCIATION OF DIRECTLY SPECIFIED MODEL EFFECTS FOR IDAHO 1976/1977/1978 SAMPLE

Effect	KABC vs O		
	LR χ^2	df	Prob.
Injury x Restraint	12.63	2	0.0018
Injury x Dr.Age	13.80	2	0.0010
Injury x Damage	219.76	6	0.000
Restraints x Child Age	111.15	6	0.000
Dr.Age x Child Age	123.37	6	0.000
Restraint x Dr.Age x Damage	14.82	4	0.0051
Summary of Model	110.13	1.04	0.3468

Therefore, Tables 3-13 to 3-16 contain the LR χ^2 values and significance levels of the directly specified effects only. A complete enumeration of both specified and hierarchically included model effects can be found in Appendix C. Chi-square values marked with an asterisk in the Appendix represent effects which were specified. All other chi-square values denote those effects which were included due to the hierarchical nature of the log-linear models.

3.4.2 Adjustment of Data

Prior to computing the actual effectiveness values, the smoothed (or "fitted") data were adjusted so as to allow for the direct comparison of injury rates. Such adjustment is necessary in order to insure that the overall effectiveness estimate will not be affected by a potentially different distribution of unrestrained children, children in child restraints and children restrained by seat belts across all levels of the control variables identified by the variable selection procedure (described in Section 3.3).

Each smoothed cell count (n_{ijk}) was adjusted to yield a corresponding smoothed, adjusted cell count (n'_{ijk}) as follows (notation is presented in Figure 3-3).

$$n'_{ijk} = n_{ijk} \left(\frac{n_{..k}}{n_{...}} \times \frac{n_{.j.}}{n_{.jk}} \right)$$

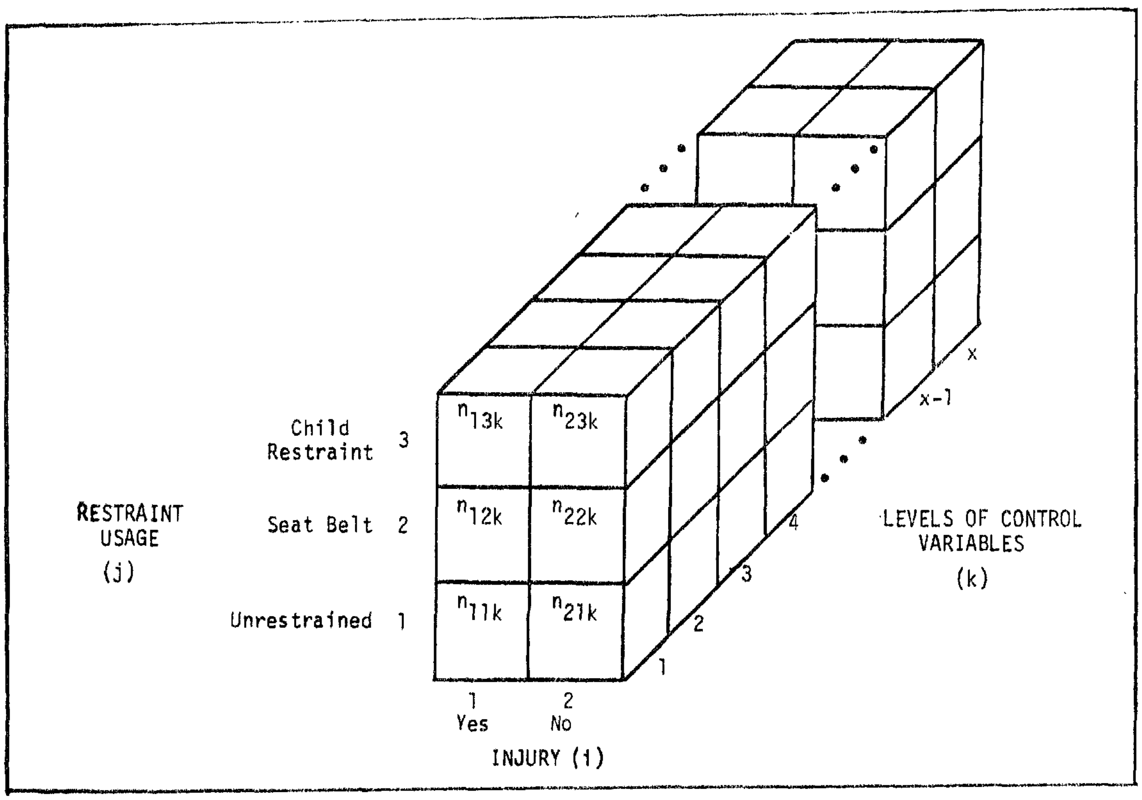

Figure 3-3. Summary of notation used to describe the data adjustment procedure.

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

(1) $n'_{i..} = n_{i..}$

(2) $n'_{.j.} = n_{.j.}$

(3) $n'_{..k} = n_{..k}$

(4) $n'_{i.k} = n_{i.k}$

(5) $n'_{ij.} = n_{ij.}$

In other words, the total number of children in each injury category does not change, nor does the total number in each restraint usage category or in each level of every control variable change.

It should be noted, however, that within each combination of Restraint Usage (j) and Level of Control Variables (k), the adjusted count will not equal the unadjusted count:

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

However, under these conditions, the injury risk does remain unchanged:

$$\frac{n'_{1jk}}{n'_{.jk}} = \frac{n_{1jk}}{n_{.jk}} .$$

After all cell counts were adjusted, the data were aggregated over all levels of all control variables, resulting in a simple Injury x Restraint Usage table for each injury dichotomy that was used for each sample. These tables served as the basis for all subsequent effectiveness computations and error estimations.

By way of summary, Table 3-17 contains the variables which, in conjunction with Injury and Restraint Usage, were used in adjusting the smoothed cell counts.

TABLE 3-17

CONTROL VARIABLES USED IN DATA ADJUSTMENT PROCEDURE

State	Year	Variables	Categories
New York	1974	Road Classification	State Highway County/Town Road City Street Limited Access Highway
		Age of Child	One Year Two Years Three Years Four Years
		Vehicle Weight	LT 3,000 lbs 3,000 - 3,599 lbs 3,600 lbs or more
		Extent of Vehicle Damage	None/Light Moderate Severe
	1977	Road Classification	State Highway County/Town Road City Street Limited Access Highway
		Vehicle Weight	LT 3,000 lbs 3,000 - 3,599 lbs 3,600 lbs or more
		Age of Driver	16 to 25 26 to 30 31 or older
New Jersey	1975	Child's Seat Position	Front Seat Back Seat
		Road Classification	State Highway County Road City Street Interstate
		City Size	LT 25,000 25,000 or more
		Age of Driver	16 to 25 26 to 30 31 or older
Idaho	1976-1978	Age of Driver	16 to 25 26 to 30 31 or older
		Age of Child	One Year Two Years Three Years Four Years
		Extent of Vehicle Damage	$500 or less $501 or more

3.4.3 Effectiveness and Error Estimation

Estimation of Effectiveness Values

As noted previously, the overall effectiveness of child restraints in reducing injuries can be expressed as:

$$E_{\text{(Child Restraints)}} = 100 \times \left[1 - \frac{p_{13.}}{p_{11.}} \right] ,$$

using the notation depicted in Figure 3-4. Cell entries in Figure 3-4 consist of smoothed, adjusted counts (n_{ijk}'s) as well as the corresponding proportions (p_{ijk}'s).

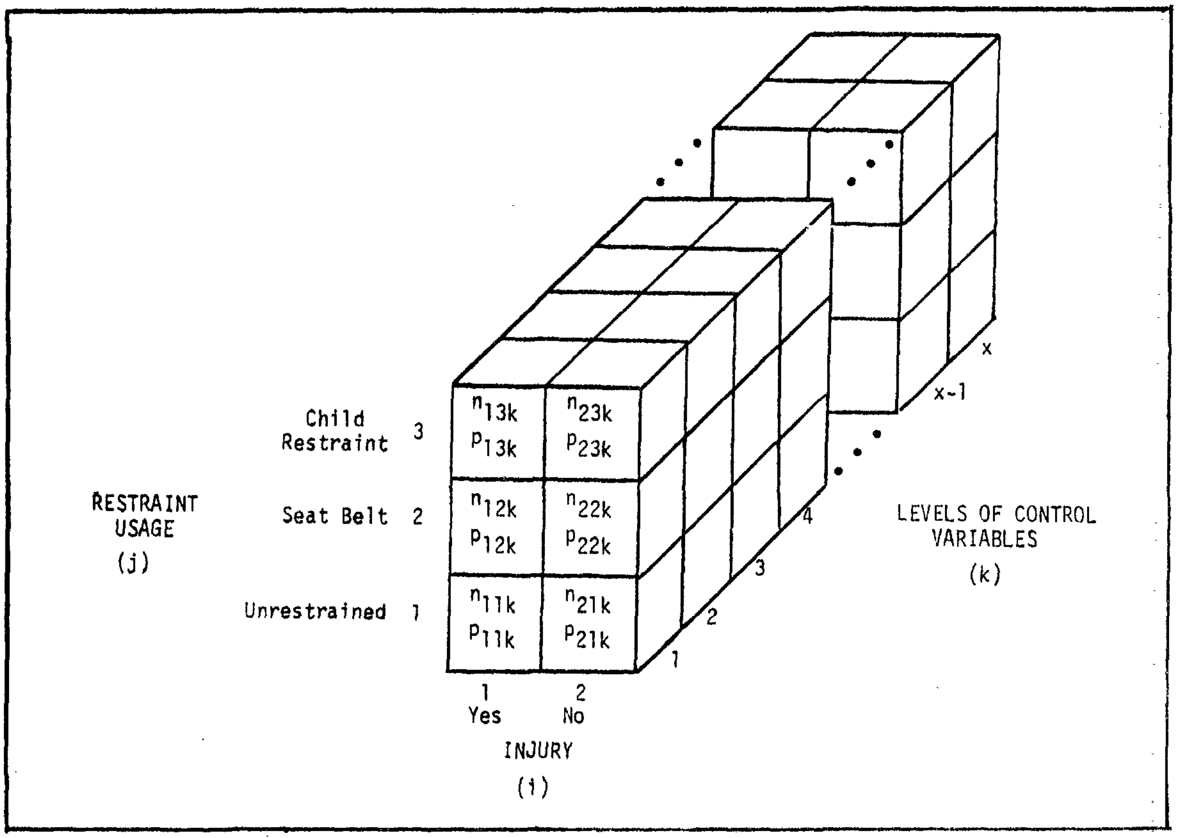

Figure 3-4. Summary of notation used to describe the effectiveness and error estimation procedures.

However, given the stochastic nature of the phenomenon under study, this equation can be written to explicitly include an error term (ε) as

$$E'_{\text{(Child Restraints)}} = 100 \times \left[1 - \left(\frac{\pi_{13.}}{\pi_{11.}} \; \frac{(1 + \varepsilon_{13.})}{(1 + \varepsilon_{11.})} \right) \right]$$

where the $\pi_{1j.}$ are the expected values of the $p_{1j.}$.

Furthermore, it is assumed that for each $p_{1j.} = n_{1j.}/n_{.j.}$, the $n_{1j.}$ are binomially distributed random variables. The term

$$r = \frac{(1+\pi_{13.})}{(1+\pi_{11.})}$$

can be approximated by expanding the fraction in a power series in $\varepsilon_{11.}$. From Appendix E, it can be seen that when expanding r (retaining terms only up to the third order), the *expected* value of r can be written as

$$r' = 1 + \frac{1-\pi_{11.}}{n_{.1.}(\pi_{11.})} - \frac{(1-\pi_{11.})(1-2\pi_{11.})}{(n_{.1.}(\pi_{11.}))^2}$$

$$+ \frac{3(1-\pi_{11.})^2}{(n_{.1.}(\pi_{11.}))^2} + \frac{(1-\pi_{11.})(1-6\pi_{11.}(1-\pi_{11.}))}{(n_{.1.}(\pi_{11.}))^3} .$$

If R is defined as $p_{13.}/p_{11.}$, then the *expected* value of R

$$R' = r'\left(\frac{\pi_{13.}}{\pi_{11.}}\right)$$

is greater than $p_{13.}/p_{11.}$. Therefore, to use R as an estimator for R' overestimates the "true" effectiveness value 1-R'. Unbiased values for child restraint effectiveness ($\hat{E}$) can be computationally derived by the following equation.

$$\hat{E}_{(\text{Child Restraints})} = 100 \times \left[1-\left(\frac{p_{13.}}{p_{11.}}\;\hat{r}\right)\right] ,$$

where $$\hat{r} = 1 + \frac{1-p_{11.}}{n_{.1.}(p_{11.})} - \frac{(1-p_{11.})(1-2p_{11.})}{(n_{.1.}(p_{11.}))^2}$$

$$+ \frac{3(1-p_{11.})^2}{(n_{.1.}(p_{11.}))^2} + \frac{(1-p_{11.})(1-6p_{11.}(1-p_{11.}))}{(n_{.1.}(p_{11.}))^3} .$$

The above can easily be adapted to seat belt effectiveness by replacing the terms $\varepsilon_{13.}$, $\pi_{13.}$ and $p_{13.}$ in the numerator with $\varepsilon_{12.}$, $\pi_{12.}$ and $p_{12.}$, respectively.

Variance of Effectiveness Values

The method for estimating the variance of effectiveness values is discussed at length in Appendix E. However, a brief summary will be presented here, along with the equations used in computing $\sigma^2_{\hat{E}}$ for either child restraints or seat belts.

Using the same notation as before, the variance of effectiveness values for child restraint usage can be expressed as

$$\sigma^2_{\hat{E}} = R^2 \left(\mu_2 (\hat{r})\right), \text{ where}$$

$$R^2 = \left(\frac{p_{13.}}{p_{11.}}\right)^2, \text{ and}$$

$$\mu_2 (\hat{r}) = \mu_2' (\hat{r}) - (\mu_1' (\hat{r}))^2.$$

The value of $\mu_2' (\hat{r})$ can be derived by

$$\mu_2' (r) = \left[1 + \frac{1-p_{13.}}{n_{.3.} (p_{13.})}\right] \times \left[1 + 3\left(\frac{1-p_{11.}}{n_{.1.} (p_{11.})}\right) - 4\left(\frac{(1-p_{11.})(1-2p_{11.})}{(n_{.1.} (p_{11.}))^2}\right) + 5\left(\frac{3(1-p_{11.})^2}{(n_{.1.} (p_{11.}))^2} + \frac{(1-p_{11.})(1-6p_{11.}(1-p_{11.}))}{(n_{.1.} (p_{11.}))^3}\right)\right],$$

while the value of $(\mu_1'(\hat{r}))^2$ can be obtained by squaring the value of $\hat{r}$, which was computed previously in the process of estimating $\hat{E}$.

Again, the above can be easily adapted to compute estimates of the variances of seat belt effectiveness values by replacing the $p_{13.}$ and $n_{.3.}$ terms in the preceeding equation by $p_{12.}$ and $n_{.2.}$, respectively.

Interval Estimation and Hypothesis Testing

As noted previously, estimates of unbiased child restraint effectiveness values and their variances were obtained by expanding the error term $r = \frac{(1+\varepsilon_{13.})}{(1+\varepsilon_{11.})}$ in a power series in $\varepsilon_{11.}$, retaining terms up to the third order only. Hence, the "true" distribution of r was approximated by using a normal distribution with the "true" mean and variance. Having derived $\sigma^2_{\hat{E}}$, 95 percent confidence intervals were computed as follows.

$$\text{Lower Limit} = \hat{E} - 1.64\sigma_{\hat{E}}$$

$$\text{Upper Limit} = \hat{E} + 1.64\sigma_{\hat{E}}$$

In all cases, the values of $\hat{E}$ and $\sigma_{\hat{E}}$ were expressed in the form of percentages.

Separate tests of the hypothesis that the obtained level of effectiveness is significantly greater than zero were carried out as a matter of course, since interval estimation and hypothesis testing are generally not equivalent. However, in this study we are dealing with a special case, in which the values of $\hat{E}$, by virtue of the way in which they were approximated, are based upon a normal distribution with a "known" σ. As a result, the results of hypothesis testing can generally be inferred from the results of the interval estimation.

In any event, the results of the separate hypothesis testing are based upon a standard test for the difference of two proportions --i.e., between the proportion of unrestrained and restrained children who are injured. The test statistic used is:

$$Z = \frac{p_1 - p_2}{\sqrt{\hat{p}\hat{q}\,(1/n_1 + 1/n_2)}},$$

where p_1 and p_2 represent the injury rates of unrestrained and restrained children, respectively. Also, $\hat{p} = \frac{p_1n_1 + p_2n_2}{n_1 + n_2}$, while $\hat{q} = 1 - \hat{p}$.

Results

Major findings, including the actual values for the effectiveness of restraint usage by children four years of age or younger are presented in this subsection. Tables 3-18 to 3-21 contain the following information for each sample and for each injury dichotomy used.

- Injury distributions presented separately for unrestrained children, for children restrained by child restraints, by seat belts, and by either device, as well as for all children.
- Separate injury rates for the above restraint usage categories, as well as for all children.
- Effectiveness values, standard deviations and 95 percent confidence intervals presented separately for children in child restraints, seat belts and either device.

Tables 3-18 and 3-19 summarize this information for New York 1974 and 1977 samples, respectively, for all three injury dichotomies. Table 3-20 contains the findings for the New Jersey 1975 sample, for KAB vs. CO and KABC vs. 0 injury dichotomies. Finally, Table 3-21 presents the results for the Idaho 1976-1978 sample, in which only a KABC vs. 0 injury dichotomy was used.

For the convenience of the reader, this information is also presented in Tables 3-22 to 3-24, and is organized somewhat differently in order to facilitate comparisons--i.e., Tables 3-22, 3-23 and 3-24 summarize all findings pertaining to child restraints, seat belts and both devices, respectively. Table 3-22 shows that accident-involved children restrained by either child restraints or seat belts sustain significantly <u>fewer</u> injuries than unrestrained children. For example, the percent reduction in the number of injuries sustained by restrained children ranges from 30 to 37 percent for K, A, B and C injuries; from 32 to 44 percent for K, A, and B injuries; and is 41 percent for K and A injuries.

When child restraint systems are considered separately (Table 3-22), fewer findings are statistically significant. However, in New York, child restraint usage results in a 28 percent reduction in K and A injuries and a 26 percent reduction in the overall incidence of K, A and B injuries, compared to a 30 percent reduction in K, A, B and C injuries, considered collectively. In New Jersey, child restraint usage results in a 20 percent reduction in overall K,A, B and K, A, B and C injuries. Effectiveness values for KA in New York 1974 and KABC in Idaho 1976-1978 are not significantly different from zero.

While effectiveness values for seat belt usage (Table 3-23) are generally one to two times higher than those for child restraint usage, one must be wary of attaching too much importance to this result, since the differences are statistically significant <u>only</u> in the case of the New Jersey 1975 sample. Table 3-25

TABLE 3-18

SUMMARY OF CHILD RESTRAINT EFFECTIVENESS STUDY USING NEW YORK 1974 DATA (SMOOTHED, ADJUSTED)

Total Cases = 9104

INJURY CATEGORIES	INJURY DISTRIBUTIONS									
	UNRESTRAINED CHILDREN		RESTRAINED CHILDREN						ALL CHILDREN	
			CHILD RESTRAINT		SEATBELT		EITHER DEVICE			
	N	%	N	%	N	%	N	%	N	%
K+A	227	2.5	20	0.2	21	0.2	41	0.5	268	2.9
B+C+O	6979	76.7	678	7.4	1179	13.0	1857	20.4	8836	97.1
K+A+B	1379	15.1	106	1.2	158	1.7	264	2.9	1643	18.0
C+O	5828	64.0	591	6.5	1042	11.4	1633	17.9	7461	82.0
K+A+B+C *	2208	24.1	155	1.7	285	3.1	440	4.8	2648	29.0
O	5032	55.0	546	6.0	920	10.1	1466	16.0	6498	71.0
K+A+B+C+O	7206	79.2	698	7.7	1200	13.2	1898	20.8	9104	100.0

INJURY CATEGORIES	INJURY RATES (PERCENT)				
	UNRESTRAINED CHILDREN	RESTRAINED CHILDREN			ALL CHILDREN
		CHILD RESTRAINT	SEATBELT	EITHER DEVICE	
K+A	3.15	2.87	1.75	2.16	2.94
K+A+B	19.13	15.21	13.17	13.92	18.05
K+A+B+C	30.50	22.11	23.65	23.08	28.95

INJURY CATEGORIES	RESTRAINT USAGE	SUMMARY OF EFFECTIVENESS VALUES (PERCENT)			
		EFFECTIVENESS	STANDARD DEVIATION	95% CONFIDENCE INTERVAL	
				FROM	TO
K+A	CHILD RESTRAINT	8.64	21.12	-26.00	43.28
	SEATBELT	44.20	12.68	23.40	65.00
	EITHER DEVICE	31.12	11.66	12.01	50.24
K+A+B	CHILD RESTRAINT	20.47	7.37	8.38	32.57
	SEATBELT	31.15	5.38	22.33	39.96
	EITHER DEVICE	27.23	4.52	19.81	34.64
K+A+B+C	CHILD RESTRAINT	27.47	5.30	18.78	36.17
	SEATBELT	22.42	4.25	15.46	29.39
	EITHER DEVICE	24.28	3.44	18.64	29.92

* Row totals for the K+A+B+C vs O injury categories do not equal the row totals for K+A+B+C+O, due to the inclusion of 43 cases classified as "injured - extent unknown."

TABLE 3-19

SUMMARY OF CHILD RESTRAINT EFFECTIVENESS STUDY USING NEW YORK 1977 DATA (SMOOTHED, ADJUSTED)

Total Cases = 9686

INJURY CATEGORIES	INJURY DISTRIBUTIONS									
	UNRESTRAINED CHILDREN		RESTRAINED CHILDREN						ALL CHILDREN	
			CHILD RESTRAINT		SEATBELT		EITHER DEVICE			
	N	%	N	%	N	%	N	%	N	%
K+A	188	1.9	13	0.1	11	0.1	24	0.2	212	2.2
B+C+O	7443	76.8	871	9.0	1160	12.0	2031	21.0	9474	97.8
K+A+B	1395	14.4	113	1.2	128	1.3	241	2.5	1636	16.9
C+O	6235	64.4	771	8.0	1043	10.8	1814	18.7	8049	83.1
K+A+B+C	2266	23.4	178	1.8	222	2.3	400	4.1	2666	27.5
O	5364	55.4	706	7.3	949	9.8	1655	17.1	7019	72.5
K+A+B+C+O	7631	78.8	884	9.1	1171	12.1	2055	21.2	9686	100.0

INJURY CATEGORIES	INJURY RATES (PERCENT)				
	UNRESTRAINED CHILDREN	RESTRAINED CHILDREN			ALL CHILDREN
		CHILD RESTRAINT	SEATBELT	EITHER DEVICE	
K+A	2.46	1.47	0.94	1.17	2.19
K+A+B	18.28	12.78	10.93	11.73	16.89
K+A+B+C	29.70	20.14	18.96	19.46	27.53

INJURY CATEGORIES	RESTRAINT USAGE	SUMMARY OF EFFECTIVENESS VALUES (PERCENT)			
		EFFECTIVENESS	STANDARD DEVIATION	95% CONFIDENCE INTERVAL	
				FROM	TO
K+A	CHILD RESTRAINT	39.99	17.19	11.80	68.17
	SEATBELT	61.66	11.90	42.15	81.18
	EITHER DEVICE	52.34	10.35	35.36	69.32
K+A+B	CHILD RESTRAINT	30.04	6.38	19.58	40.51
	SEATBELT	40.18	5.20	31.65	48.71
	EITHER DEVICE	35.82	4.19	28.95	42.69
K+A+B+C	CHILD RESTRAINT	32.18	4.70	24.47	39.88
	SEATBELT	36.14	4.02	29.55	42.74
	EITHER DEVICE	34.44	3.16	29.25	39.62

TABLE 3-20

SUMMARY OF CHILD RESTRAINT EFFECTIVENESS STUDY USING NEW JERSEY 1975 DATA (SMOOTHED, ADJUSTED)

Total Cases = 6719

INJURY CATEGORIES	INJURY DISTRIBUTIONS									
	UNRESTRAINED CHILDREN		RESTRAINED CHILDREN						ALL CHILDREN	
			CHILD RESTRAINT		SEATBELT		EITHER DEVICE			
	N	%	N	%	N	%	N	%	N	%
K+A+B	646	9.6	64	1.0	46	0.7	110	1.6	756	11.3
C+O	4509	67.1	569	8.5	885	13.2	1454	21.6	5963	88.7
K+A+B+C	1736	25.8	171	2.5	162	2.4	333	5.0	2069	30.8
O	3418	50.9	462	6.9	770	11.5	1232	18.3	4650	69.2
K+A+B+C+O	5155	76.7	633	9.4	931	13.9	1564	23.3	6719	100.0

INJURY CATEGORIES	INJURY RATES (PERCENT)				
	UNRESTRAINED CHILDREN	RESTRAINED CHILDREN			ALL CHILDREN
		CHILD RESTRAINT	SEATBELT	EITHER DEVICE	
K+A+B	12.53	10.11	4.94	7.03	11.25
K+A+B+C	33.68	27.01	17.38	21.28	30.79

INJURY CATEGORIES	RESTRAINT USAGE	SUMMARY OF EFFECTIVENESS VALUES (PERCENT)			
		EFFECTIVENESS	STANDARD DEVIATION	95% CONFIDENCE INTERVAL	
				FROM	TO
K+A+B	CHILD RESTRAINT	19.21	10.05	2.73	35.68
	SEATBELT	60.52	5.87	50.89	70.14
	EITHER DEVICE	43.80	5.58	34.65	52.95
K+A+B+C	CHILD RESTRAINT	19.77	5.47	10.79	28.75
	SEATBELT	48.38	3.82	42.10	54.65
	EITHER DEVICE	36.80	3.31	31.37	42.24

TABLE 3-21

SUMMARY OF CHILD RESTRAINT EFFECTIVENESS STUDY USING IDAHO 1976-1978 DATA (SMOOTHED, ADJUSTED)

Total Cases = 3509

INJURY CATEGORIES	INJURY DISTRIBUTIONS									
	UNRESTRAINED CHILDREN		RESTRAINED CHILDREN						ALL CHILDREN	
			CHILD RESTRAINT		SEATBELT		EITHER DEVICE			
	N	%	N	%	N	%	N	%	N	%
K+A+B+C	549	15.6	21	0.6	36	1.0	57	1.6	606	17.3
O	2504	71.4	113	3.2	286	8.2	399	11.4	2903	82.7
K+A+B+C+O	3053	87.0	134	3.8	322	9.2	456	13.0	3509	100.0

INJURY CATEGORIES	INJURY RATES (PERCENT)				
	UNRESTRAINED CHILDREN	RESTRAINED CHILDREN			ALL CHILDREN
		CHILD RESTRAINT	SEATBELT	EITHER DEVICE	
K+A+B+C	17.98	15.67	11.18	12.50	17.27

INJURY CATEGORIES	RESTRAINT USAGE	SUMMARY OF EFFECTIVENESS VALUES (PERCENT)			
		EFFECTIVENESS	STANDARD DEVIATION	95% CONFIDENCE INTERVAL	
				FROM	TO
K+A+B+C	CHILD RESTRAINT	12.72	17.84	-16.53	41.97
	SEATBELT	37.73	10.09	21.19	54.28
	EITHER DEVICE	30.38	9.06	15.53	45.23

TABLE 3-22

SUMMARY OF OVERALL RESTRAINT USAGE (CHILD RESTRAINTS OR SEAT BELTS) EFFECTIVENESS VALUES FOR CHILDREN 0-4 YEARS OF AGE* DERIVED FROM SMOOTHED, ADJUSTED MASS ACCIDENT DATA

Injury Level	State	Year	Unbiased Effectiveness (%)	Standard Deviation	95% Confidence Interval		Is Effectiveness Significantly Different from Zero
					From	To	
K+A	New York	1974	31.1	11.7	12.0	50.2	Yes
		1977	52.3	10.4	35.4	69.3	Yes
		1974 & 1977 **	42.9	7.8	30.2	55.7	Yes
K+A+B	New York	1974	27.2	4.5	19.8	34.6	Yes
		1977	35.8	4.2	29.0	42.7	Yes
		1974 & 1977 **	31.8	3.1	26.8	36.8	Yes
	New Jersey	1975	43.8	5.6	34.6	53.0	Yes
K+A+B+C	New York	1974	24.3	3.4	18.6	29.9	Yes
		1977	34.4	3.2	29.2	39.6	Yes
		1974 & 1977 **	29.7	2.3	25.8	33.5	Yes
	New Jersey	1975	36.8	3.3	31.4	42.2	Yes
	Idaho	1976-1978	30.4	9.1	15.5	45.2	Yes

*In New Jersey and Idaho, the age range of children is 1-4 years.

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

TABLE 3-23

SUMMARY OF OVERALL SEAT BELT EFFECTIVENESS VALUES FOR CHILDREN 0-4 YEARS OF AGE* DERIVED FROM SMOOTHED, ADJUSTED MASS ACCIDENT DATA

Injury Level	State	Year	Unbiased Effectiveness (%)	Standard Deviation	95% Confidence Interval		Is Effectiveness Significantly Different from Zero
					From	To	
K+A	New York	1974	44.2	12.7	23.4	65.0	Yes
		1977	61.7	11.9	42.2	81.2	Yes
		1974 &** 1977	53.5	8.7	39.2	67.7	Yes
K+A+B	New York	1974	31.2	5.4	22.3	40.0	Yes
		1977	40.2	5.2	31.6	48.7	Yes
		1974 & ** 1977	35.8	3.7	29.7	42.0	Yes
	New Jersey	1975	60.5	5.9	50.9	70.1	Yes
K+A+B+C	New York	1974	22.4	4.2	15.5	29.4	Yes
		1977	36.1	4.0	29.6	42.7	Yes
		1974 & ** 1977	29.7	2.9	24.9	34.4	Yes
	New Jersey	1975	48.4	3.8	42.1	54.6	Yes
	Idaho	1976-1978	37.7	10.1	21.2	54.3	Yes

*In New Jersey and Idaho, the age range of children is 1-4 years.

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

TABLE 3-24

SUMMARY OF OVERALL CHILD RESTRAINT EFFECTIVENESS VALUES FOR CHILDREN 0-4 YEARS OF AGE* DERIVED FROM SMOOTHED, ADJUSTED MASS ACCIDENT DATA

Injury Level	State	Year	Unbiased Effectiveness (%)	Standard Deviation	95% Confidence Interval		Is Effectiveness Significantly Different from Zero
					From	To	
K+A	New York	1974	8.6	21.1	-26.0	43.4	No
		1977	40.0	17.2	11.8	68.2	Yes
		1974 & ** 1977	27.5	13.3	5.6	49.4	Yes
K+A+B	New York	1974	20.5	7.4	8.4	32.6	Yes
		1977	30.0	6.4	19.6	40.5	Yes
		1974 & ** 1977	25.9	4.8	18.0	33.8	Yes
	New Jersey	1975	19.2	10.0	2.7	35.7	Yes
K+A+B+C	New York	1974	27.5	5.3	18.8	36.2	Yes
		1977	32.2	4.7	24.5	39.9	Yes
		1974 & ** 1977	30.1	3.5	24.3	35.9	Yes
	New Jersey	1975	19.8	5.5	10.8	28.8	Yes
	Idaho	1976-1978	12.7	17.8	-16.5	42.0	No

*In New Jersey and Idaho, the age range of children is 1-4 years.

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

presents the results of tests of the statistical significance of differences between seat belt and child restraint effectiveness values derived from smoothed, adjusted mass accident data. These findings suggest that almost all observed differences between the measured effectiveness of seat belts and child restraints in reducing both the frequency and severity of injuries are most likely due to chance.

With regard to the percent reduction in the severity of injuries sustained by restrained children, findings are suggestive only. For example, there appears to be a very slight trend whereby effectiveness values of child restraint usage decrease somewhat as the definition of the "injured" category narrows. In New York, there is a shift in child restraint effectiveness values from 30 percent to 26 percent to 24 percent for the KABC, KAB and KA injury categories, respectively. In New Jersey, effectiveness for KA is not computed because of small sample size, and the corresponding values for KABC and KAB are roughly equal.

Seat belt effectiveness shows the opposite trend. For example, effectiveness values for New York are 29, 36 and 52 percent for KABC, KAB and KA injury categories. The greatest difference occurs between the KA and KAB dichotomies. In New Jersey, the corresponding percentages are 48 and 60, for KABC and KAB, respectively.

It should be noted that, given the variability of the individual effectiveness values, these trends are slight, and are just as likely due to chance. Furthermore, the consistency of such trends is difficult to assess, insofar as all three injury dichotomies were not used for New Jersey and Idaho samples.

Finally, Table 3-26 summarizes all effectiveness values derived from observed, unadjusted data as well as from smoothed, adjusted data. From this table, it can be seen that on the average, the net effect of smoothing and adjusting the data was to decrease effectiveness values by roughly 1 to 5 percentage points for New York samples, and to increase effectiveness values by 4 to 8 percentage points for the Idaho sample. In the case of the New Jersey sample, modeling and adjustment had no appreciable impact on effectiveness values.

In any event, given the lack of detail characterizing state mass accident data bases with respect to the make and type of child restraint systems used, and to whether they are misused or not, one can safely conclude that the observed effectiveness values reported here most probably underestimate the reduction in injuries gained from the proper use of FMVSS 213 child restraints.

TABLE 3-25

STATISTICAL SIGNIFICANCE* OF DIFFERENCES BETWEEN SEAT BELT AND CHILD RESTRAINT EFFECTIVENESS VALUES DERIVED FROM SMOOTHED, ADJUSTED MASS ACCIDENT DATA

Injury Level	State	Year	Seat Belt Effectiveness (%)	Seat Belt Effectiveness (s.d)	Child Restraint Effectiveness (%)	Child Restraint Effectiveness (s.d)	Difference (%)	Difference (s.d)	Is Difference Statistically Significant?
K+A	New York	1974	44.2	12.7	8.6	21.1	35.6	24.6	No
		1977	61.7	11.9	40.0	17.2	21.7	20.9	No
		1974 & ** 1977	53.5	8.7	27.5	13.3	26.0	15.9	No
K+A+B	New York	1974	31.2	5.4	20.5	7.4	10.7	9.1	No
		1977	40.2	5.2	30.0	6.4	10.1	8.2	No
		1974 & ** 1977	35.8	3.7	25.9	4.8	9.9	6.1	No
	New Jersey	1975	60.5	5.9	19.2	10.0	41.3	11.6	Yes
K+A+B+C	New York	1974	22.4	4.2	27.5	5.3	-5.0	6.8	No
		1977	36.1	4.0	32.2	4.7	4.0	6.2	No
		1974 & ** 1977	29.7	2.9	30.1	3.5	-0.4	4.6	No
	New Jersey	1975	48.4	3.8	19.8	5.5	28.6	6.7	Yes
	Idaho	1976-1978	37.7	10.1	12.7	17.8	25.0	20.5	No

*Two-tailed test, $\alpha = 0.05$

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

TABLE 3-26

SUMMARY OF OVERALL EFFECTIVENESS VALUES FOR CHILDREN 0-4 YEARS OF AGE †

Restraint	Injury Level	State	Year	Observed, Unadjusted Data: Effectiveness (Percent)	Standard Deviation	95 % Confidence Interval From	To	Is Effectiveness Significantly Different From Zero?
Child Restraint	K+A	New York	1974 1977 1974 & 77*	22.2 40.0 32.2	19.4 17.2 12.9	-9.6 11.8 11.1	54.1 68.2 53.3	No Yes Yes
	K+A+B	New York	1974 1977 1974 & 77*	23.2 29.3 26.6	7.2 6.4 4.8	11.3 18.8 18.8	35.0 39.8 34.4	Yes Yes Yes
		New Jersey	1975	18.0	10.1	1.4	34.6	Yes
	K+A+B+C	New York	1974 1977 1974 & 77*	34.2 29.9 31.9	5.1 4.8 3.5	26.0 22.0 26.2	42.6 37.7 37.6	Yes Yes Yes
		New Jersey	1975	19.8	5.5	10.8	28.8	Yes
		Idaho	1976-1978	4.6	18.5	-25.8	34.9	No
Seat Belt	K+A	New York	1974 1977 1974 & 77*	46.9 61.7 54.6	12.4 11.9 8.6	26.6 42.2 40.5	67.1 81.2 68.7	Yes Yes Yes
	K+A+B	New York	1974 1977 1974 & 77*	32.8 42.0 37.6	5.3 5.1 3.7	24.2 33.6 31.6	41.5 50.4 43.6	Yes Yes Yes
		New Jersey	1975	60.5	5.9	51.0	70.2	Yes
	K+A+B+C	New York	1974 1977 1974 & 77*	24.6 37.8 31.5	4.2 4.0 2.9	17.8 31.3 26.8	31.4 44.4 36.3	Yes Yes Yes
		New Jersey	1975	47.4	3.9	41.0	53.7	Yes
		Idaho	1976-1978	41.3	9.8	25.2	57.4	Yes
Either Device	K+A	New York	1974 1977 1974 & 77*	37.8 52.4 45.5	11.0 10.4 7.6	19.8 35.4 33.1	55.8 69.3 57.9	Yes Yes Yes
	K+A+B	New York	1974 1977 1974 & 77*	29.3 36.5 33.1	4.4 4.2 3.0	22.0 29.7 28.1	36.6 43.4 38.0	Yes Yes Yes
		New Jersey	1975	43.3	5.6	34.1	52.5	Yes
	K+A+B+C	New York	1974 1977 1974 & 77*	28.1 34.4 31.4	3.3 3.2 2.3	22.7 29.2 27.6	33.6 39.6 35.1	Yes Yes Yes
		New Jersey	1975	36.2	3.3	30.7	41.6	Yes
		Idaho	1976-1978	30.5	9.0	15.7	45.3	Yes

†In New Jersey and Idaho, the age range of children is 1-4 years old.

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

TABLE 3-26 (Continued)

SUMMARY OF OVERALL EFFECTIVENESS VALUES FOR CHILDREN 0-4 YEARS OF AGE ≠

Restraint	Injury Level	State	Year	Smoothed, Adjusted Data: Effectiveness (Percent)	Standard Deviation	95 % Confidence Interval: From	To	Is Effectiveness Significantly Different From Zero?
Child Restraint	K+A	New York	1974	8.6	21.1	-26.0	43.4	No
			1977	40.0	17.2	11.8	68.2	Yes
			1974 & 77*	27.5	13.3	5.6	49.4	Yes
	K+A+B	New York	1974	20.5	7.4	8.4	32.6	Yes
			1977	30.0	6.4	19.6	40.5	Yes
			1974 & 77*	25.9	4.8	18.0	33.8	Yes
		New Jersey	1975	19.2	10.0	2.7	35.7	Yes
	K+A+B+C	New York	1974	27.5	5.3	18.8	36.2	Yes
			1977	32.2	4.7	24.5	39.9	Yes
			1974 & 77*	30.1	3.5	24.3	35.9	Yes
		New Jersey	1975	19.8	5.5	10.8	28.8	Yes
		Idaho	1976-1978	12.7	17.8	-16.5	42.0	No
Seat Belt	K+A	New York	1974	44.2	12.7	23.4	65.0	Yes
			1977	61.7	11.9	42.2	81.2	Yes
			1974 & 77*	53.5	8.7	39.2	67.7	Yes
	K+A+B	New York	1974	31.2	5.4	22.3	40.0	Yes
			1977	40.2	5.2	31.6	48.7	Yes
			1974 & 77*	35.8	3.7	29.7	42.0	Yes
		New Jersey	1975	60.5	5.9	50.9	70.1	Yes
	K+A+B+C	New York	1974	22.4	4.2	15.5	29.4	Yes
			1977	36.1	4.0	29.6	42.7	Yes
			1974 & 77*	29.7	2.9	24.9	34.4	Yes
		New Jersey	1975	48.4	3.8	42.1	54.6	Yes
		Idaho	1976-1978	37.7	10.1	21.2	54.3	Yes
Either Device	K+A	New York	1974	31.1	11.7	12.0	50.2	Yes
			1977	52.3	10.4	35.4	69.3	Yes
			1974 & 77*	42.9	7.8	30.2	55.7	Yes
	K+A+B	New York	1974	27.2	4.5	19.8	34.6	Yes
			1977	35.8	4.2	29.0	42.7	Yes
			1974 & 77*	31.8	3.1	26.8	36.8	Yes
		New Jersey	1975	43.8	5.6	34.6	53.0	Yes
	K+A+B+C	New York	1974	24.3	3.4	18.6	29.9	Yes
			1977	34.4	3.2	29.2	39.6	Yes
			1974 & 77*	29.7	2.3	25.8	33.5	Yes
		New Jersey	1975	36.8	3.3	31.4	42.2	Yes
		Idaho	1976-1978	30.4	9.1	15.5	45.2	Yes

≠ In New Jersey and Idaho, the age range of children is 1-4 years old.

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

3.4.4 Extrapolation to the Nation

Using New York child restraint effectiveness estimates, it is possible (for heuristic purposes) to extrapolate to the nation, although the resulting estimates of the actual and potential reduction in injuries and fatalities that do result and could result from the use of child restraints are obviously approximate. The estimates given below pertain solely to child restraint usage and do not consider the additional savings in injuries and lives that result from the use of seat belts and shoulder straps, especially with children two years or older. It is further noted that the extrapolation is restricted to children and infants less than three years old, because actual usage of child seating systems declines to a very small percentage (less than 3 percent) for older children.

In the extrapolation, the following assumptions and use of data are critical:

- The actual effectiveness value for child restraint usage to be applied is 30 percent. This represents the weighted mean of New York 1974 and New York 1977 data effectiveness values, which were derived using a KABC vs. 0 injury dichotomy. However, this effectiveness is assumed to apply to all injury levels.

- The usage rates used for zero (less than 12 months), one and two year olds are 20 percent, 10 percent and 5 percent, respectively. These rates are reasonably conservative and representative of previous surveys.

- The percentages of child occupant fatalities relative to all occupant fatalities (0.654 percent for zero year olds, 0.540 percent for one year olds and 0.547 percent for two year olds) were determined from FARS 1976 data. The percentages of child occupant injury at each AIS level were assumed to be the same as those for fatalities.

With the above assumptions in mind, the extrapolation of child seating system effectiveness to national estimates of injuries and fatalities saved proceeds in the following manner:

1. The total number of automobile occupant fatalities and injuries in the United States for AIS levels 1 through 5 are estimated using 1977 FARS data and NCSS ratios of OAIS injuries-to-fatalities.

2. The number of child occupants of zero, one and two years of age are computed.

3. For each age level, the casualties that would result if no child seating systems were available or used (0 percent usage) are determined.

4. A similar computation as (3) is performed assuming that every child 2 years of age or less is in a child seat (100 percent usage).

5. The actual reduction in fatalities and injuries for zero to two year old children is obtained by subtracting the actual fatalities and injuries from the fatalities and injuries that would occur if no child seating systems were used (0 percent usage).

6. The potential reduction in fatalities and injuries is computed by subtracting the fatalities and injuries for 100 percent usage from those obtained with 0 percent usage.

Before presenting and discussing the results, the formulas for carrying out steps 3 and 4 will be given. The effectiveness E is defined by:

$$E = \frac{p_1 - p_2}{p_1} ,$$

where P_1 is the injury probability for unrestrained children and P_2 is the injury probability for children in child seating systems. This equation can be rewritten as:

$$p_2 = p_1 (1 - E) .$$

The relationship between the number of injuries (n) and the total population (N) can be expressed as:

$$n = N \left[u \cdot p_2 + (1 - u) p_1 \right] ,$$

where u is the assumed usage rate for child seating systems. If we substitute for p_2 it can be easily shown that:

$$n = N p_1 (1 - u E).$$

Rearranging terms, the total population N is written as:

$$N = \frac{n}{p_1 (1 - u E)} .$$

The number of injuries when everyone is restrained, n_r, is given by:

$$n_r = Np_2 = Np_1 (1 - E) = \frac{n}{(1 - u E)} (1 - E).$$

Similarly, the number of injuries when no one is restrained, n_u, is expressed as:

$$n_u = Np_1 = \frac{n}{(1 - uE)} .$$

The equations for n_r and n_u are used to compute the number of casualties assuming 100 percent vs. 0 percent child restraint usage, respectively. As noted above, the usage rate values (u) assumed for child seating systems are 20 percent, 10 percent and 5 percent for zero, one and two year-old children, respectively.

Estimates of the number of child occupants who were either killed or injured in motor vehicle accidents in 1977 are depicted in Table 3-27. The results of the extrapolation of effectiveness of child seating systems to national estimates of fatalities and casualties avoided are shown in Table 3-28.

With the current low usage rates of child seating systems, it is estimated that roughly 1440 injuries and 19 fatalities are prevented in children two years of age and younger through the use of child seats. About 900 of the injuries and 11 of the fatalities avoided occur in children under one year old. The potential savings are, of course, much greater if usage rates for child seating systems are, in fact, higher than estimated here. If 100 percent usage of child seats were assumed, about 12,000 injuries and 150 fatalities could be prevented in children two years of age and younger. This includes 4,500 injuries and 57 fatalities in children under one year old.

In the above estimates of actual and potential savings of injuries and fatalities, it should be noted that no assumption has been made about the correct usage of child seats or about the particular types of child seats currently being used. Thus, the estimates of potential savings in injuries and fatalities that result from the universal use of child seats implicitly reflect the present degree of correct and incorrect use, as well as the particular variety of types of child seats currently in use, including those which do not meet the requirements of FMVSS 213. Hence, these extrapolated estimates most likely underestimate the potential reduction in both the frequency and severity of injuries to be gained from the proper use of FMVSS 213 child restraints.

TABLE 3-27

NUMBER OF ACCIDENT-INVOLVED CHILD OCCUPANTS
EITHER KILLED OR INJURED IN 1977

Severity	Number of Child Auto Occupant Casualties 1977*	Number of Auto Occupants of Indicated Age (n)		
		0 Year 0.654 %	1 Year 0.540 %	2 Year 0.547 %
Fatalities	27,353	179	148	150
AIS 5 (Nonfatal)	2,750	18	15	16
AIS 4 (Nonfatal)	11,000	72	59	66
AIS 3	69,000	451	373	377
AIS 2	137,000	896	740	749
AIS 1	1,910,000	12,491	10,314	10,477
Total	2,157,103	14,107	11,649	11,805

*Source: Kahane, C.J., *An Evaluation of Standard 214*, U.S. Department of Transportation, NHTSA Office of Program Evaluation, September 1979, p. 145.

TABLE 3-28

NATIONAL ESTIMATES OF CASUALTIES ACTUALLY AND POTENTIALLY PREVENTED BY CHILDREN 0-2 USING CHILD RESTRAINTS

Child Age	AIS Injury Severity	Casualties if 0 % Restrained	Casualties if 100 % Restrained	Actual Savings* in Casualties	Potential Savings** in Casualties
0	Fatalities	190	133	11	57
	5	19	13	1	6
	4	77	54	5	23
	3	480	336	29	144
	2	953	667	57	286
	1	13,288	9,302	797	3,986
	Total	15,007	10,505	900	4,502
1	Fatalities	153	107	5	46
	5	15	11	0	4
	4	61	43	2	18
	3	384	269	11	115
	2	763	534	23	229
	1	10,633	7,443	319	3,190
	Total	12,009	8,407	360	3,603
2	Fatalities	153	107	3	46
	5	16	11	0	5
	4	67	47	1	20
	3	383	268	6	115
	2	760	532	11	228
	1	10,606	7,424	159	3,182
	Total	11,985	8,389	180	3,596
0-2	Fatalities	496	347	19	149
	5	50	35	1	15
	4	205	144	8	61
	3	1,247	873	46	374
	2	2,476	1,733	91	743
	1	34,527	24,169	1,275	10,358
	Total	39,001	27,301	1,440	11,700

*Assumes use rate of 20% for zero-, 15% for one-, and 10% for two-year old children.

**Assumes 100% use rate.

APPENDIX A

SUMMARY OF BACKGROUND CHARACTERISTICS OF IDAHO, NEW JERSEY AND NEW YORK SAMPLES

APPENDIX A

SUMMARY OF BACKGROUND CHARACTERISTICS OF IDAHO, NEW JERSEY AND NEW YORK SAMPLES

This Appendix contains simple tabulations for New Jersey, Idaho (pooled) and New York samples as follows:

- Idaho: 1976,1977,1978 (3,766 cases)
- New Jersey: 1975 (6,738 cases)
- New York: 1974 (10,745 cases)
- New York: 1977 (11,092 cases)

In general, for passenger car accidents involving children of ages 1, 2, 3 and 4 years, the univariate and bivariate tabulations for Idaho, New Jersey and New York show:

- Over one-half of the drivers are female. *(Table 1)*
- More than two-thirds of all drivers are age 25 or older. *(Table 2)*
- Children 1, 2, 3 and 4 years of age in accidents are approximately uniformly distributed in age, with the exception that in Idaho and New York (1977), one-year old children in accidents occur slightly more frequently than older children. The higher number of one-year-olds in New York, however, is due to coding procedures which include infants in this category. In the case of Idaho, the data suggest the *possible* inclusion of infants in the one-year-old category, which might be attributed to errors in police reporting with respect to infants' age. *(Table 3)*
- Male children appear in accidents slightly more frequently than female children. *(Table 4)*
- In Idaho, roughly 18 percent of the children in accidents were injured, compared to 31 and 28 percent of children in New Jersey and New York, respectively. Type B injuries account for 10-15 percent of the cases in the three states, but New Jersey children have 3.4 more Type C injuries than Idaho children (5.7 percent in Idaho; 19.6 percent in New Jersey) and nearly twice as many Type C injuries as New York children. Type A injuries are three times more frequent in New York, compared with New Jersey (2.5 percent in New York; 0.8 percent in New Jersey). Also, children are more likely to be killed in Idaho accidents (0.2 percent) compared to New Jersey (0.4 percent) and New York (0.1 percent). *(Table 5)*
- The usage rates of child seats in New Jersey and New York are at least twice the Idaho rate (3.8 percent). Also, the usage rates for seat belts (including shoulder straps) in New Jersey and New York are approximately 1.5 times greater than in Idaho (8.8 percent). *(Table 6)*
- In Idaho, about 60 percent of accident-involved children ride in the front seat, with slightly more than half of these occupying the front center seat. In New York and New Jersey, roughly one-half of the children ride in the front seat, with equal frequency of front right and front center seat occupancy. The three rear seat positions have approximately equal probability of occupancy in Idaho and New York. However, in New Jersey, the left rear seat is more frequently occupied than the other two. *(Table 7)*

- On an overall basis, the reduction in injury risk due to child restraint usage ranges from 13 percent (Idaho) to 36 percent (New York 1974). For children in seat belts, the range is 27 percent (Idaho) to 48 percent (New Jersey). These reductions are relative to the injury risks of unrestrained children. With the exception of New York (1974), the injury rates of children in seatbelts are consistently lower than those of children using child restraints. *(Table 8)*
- The probability of children being injured is approximately independent of age in both Idaho and New Jersey. In New York, however, where infants are included in the samples, the injury rate of children increased with age. *(Table 9)*
- In all three states, children in the front seat were more likely to be injured than children in the rear seat. *(Table 10)*
- Of the children (at least one-year olds)* using child restraints, nearly two-thirds are one year old (65 percent in Idaho; 63 percent in New Jersey; 64 percent in New York). Four year old children were four to five times more likely to be restrained by seat belts, rather than child seats. At age three, they are two to three times more likely to be restrained by seat belts, while at age two, the usage rates are approximately the same. *(Table 12)*
- Children in either child restraints or seat belts are approximately equally likely to be found in front or rear seats. *(Table 13)*
- Two-thirds to three-quarters (77 percent in Idaho; 71 percent in New Jersey; 64 percent in New York) of one-year-old children are found in front seats. As the children grow older, they shift to the rear seat, so that by age four, over half ride in the rear seat (52 percent in Idaho; 59 percent in New Jersey; 61 percent in New York). *(Table 14)*

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*Because of procedures used in data recording and handling, neither the Idaho nor the New Jersey data base has information on children less than one year old. However, the age distribution of children in Idaho suggests that the one-year-old category might in fact include some infants, possibly as a result of police reporting errors with respect to the age of children less than one year old.

1.0 DRIVER SEX

Drivers of cars in accidents in which children one to four years old are involved are more likely to be female.

TABLE 1

DRIVER SEX IN PASSENGER CAR ACCIDENTS
INVOLVING CHILDREN (1-4) AS PASSENGERS

Driver Sex	Idaho	New Jersey	New York	
Female	64.7 %	60.4 %	53.9 %	53.1 %
Male	25.3	39.6	46.1	46.9
No. of Cases	3,766	6,729	10,745	11,092
Year(s)	76, 77, 78	75	74	77

2.0 DRIVER AGE

The drivers in passenger car accidents involving children 1-4 are predominantly 25 years of age or older. However, accident-involved drivers in Idaho are younger than drivers in New Jersey and New York.

TABLE 2

DRIVER AGE, BY SEX, IN PASSENGER CAR ACCIDENTS
INVOLVING CHILDREN (1-4) AS PASSENGERS

Driver Sex	Age	Idaho	New Jersey	New York 1974	New York 1977
Female	≥ 25	63.4 %	79.6 %	70.6 %	71.5 %
	< 25	36.6	20.4	29.4	28.5
Male	≥ 25	74.7	83.6	76.7	78.4
	< 25	25.3	16.4	23.3	21.6
No. of Cases		3,713	6,718	10,640	11,024

3.0 CHILD AGE

Children in accidents are essentially uniformly distributed by age; the higher incidence of one-year-olds in New York 1977 is due to the fact that infants (less than one year old) are included in this category. Since 1974, police in New York State have reported the age of occupants 23 months or younger as one year old. Furthermore, the higher number of one-year-olds in Idaho suggests that some infants may have also been included in this category, possibly as a result of reporting errors with respect to the age of infants and very young children.

TABLE 3

CHILD AGE IN PASSENGER CAR ACCIDENTS

Child Age	Idaho	New Jersey	New York 1974	New York 1977
One	29.5 %	25.8 %	25.1 %	29.4 %
Two	26.8	23.2	23.6	24.0
Three	22.6	25.4	26.0	23.6
Four	21.1	25.6	25.3	22.9
No. of Cases	3,766	6,738	10,745	11,092

4.0 CHILD SEX

Male and female children in accidents are essentially equally probable, although males are slightly more probable than females.

TABLE 4

SEX OF CHILDREN (1-4) IN PASSENGER CAR ACCIDENTS

Child Sex	Idaho	New Jersey	New York 1974	New York 1977
Male	50.3 %	51.8 %	52.0 %	51.3 %
Female	49.7	48.2	48.0	48.7
No. of Cases	3,755	6,702	10,685	11,060

5.0 CHILD INJURY RATES

Injury rates of children in accidents range from 18 percent (Idaho) to 31 percent (New Jersey). It appears that Idaho and New York are less likely to classify very minor "injuries" as Type C injuries than in New Jersey. Only 32 to 39 percent of all injuries are Type C in Idaho and New York *vs.* 63.5 of all injuries in New Jersey.

TABLE 5

INJURY RATES FOR CHILDREN (1-4) IN PASSENGER CAR ACCIDENTS

Injury Classification	Idaho		New Jersey		New York 1974		New York 1977	
0	82.4 %	Injury Distribution	69.0 %	Injury Distribution	71.2 %	Injury Distribution	72.5 %	Injury Distribution
C	5.7	32.2 %	19.6	63.5 %	10.4	36.1 %	10.7	39.0 %
B	9.8	55.7	10.5	33.9	15.2	52.7	14.5	52.8
A	1.9	11.1	0.8	2.5	2.7	9.5	2.2	7.8
K	0.2	1.1	0.04	0.14	0.1	0.3	0.1	0.4
Injured Extent Unknown	--	--	--	--	0.4	1.4	--	--
None (0)	82.4 %		69.0 %		71.2 %		72.5 %	
C+B+A+K	17.6		31.0		28.8		27.5	
No. of Cases	3,766		6,738		10,745		11,092	

6.0 RESTRAINT USAGE

From 13 percent (Idaho) to 23 percent (New Jersey) of children age 1-4 in accidents use either seat belts or child restraints. Children in New Jersey are 2.5 times as likely to be in child seats than in Idaho. The New Jersey children are 1.6 times as likely to be in seat belts. Overall, New Jersey children are 1.8 times more likely than Idaho children to be in seat belts or child restraints. Restraint usage rates for New York children in both 1974 and 1977 fall between the rates of the above two states, but are considerably closer to New Jersey.

TABLE 6

USE OF RESTRAINTS BY CHILDREN (1-4) IN PASSENGER CAR ACCIDENTS

Restraint Usage	Idaho		New Jersey		New York 1974		New York 1977	
Child Seat	3.8 %	12.6 %	9.4 %	23.2 %	7.4 %	20.5 %	8.8 %	20.8 %
Seat Belt*	8.8		13.8		13.1		12.0	
No Restraint	87.3		76.8		79.5		79.2	
No. of Cases	3,766		6,738		10,745		11,092	

*Includes belt with shoulder strap.

7.0 SEATING POSITION

Between 49 percent (New York 1974) and 61 percent (Idaho) of all children in accidents are in the front seat. In New Jersey and New York, these children are found in the front center or front right seats with approximately equal probability. However, in Idaho, they are more likely to be sitting in the front right seat.

TABLE 7

SEATING POSITION OF CHILDREN (1-4) IN PASSENGER CAR ACCIDENTS

Seat Position	Idaho	New Jersey	New York 1974	New York 1975
Front Seat	60.7 %	53.5 %	49.3 %	50.1 %
• Front Center	27.1	26.5	25.4	25.4
• Front Right	33.6	26.9	23.9	24.7
Rear Seat	39.3 %	46.5 %	50.7 %	49.9 %
• Rear Left	12.9	20.5	16.8	16.1
• Rear Center	14.2	13.1	15.5	16.2
• Rear Right	12.1	12.9	18.4	17.6
No. of Cases	3,766	6,738	10,745	11,092

8.0 INJURED/UNINJURED FREQUENCIES, BY RESTRAINT USAGE

Children using seat belts or child restraints are more likely to avoid injury than unrestrained children. Children in seat belts are less likely to be injured than children in child seats in Idaho and New Jersey. In New York 1974, children using child restraints have the lowest injury rate. However, in New York 1977, the injury rate is lower for seat belts, as is the case in Idaho and New Jersey.

TABLE 8

FREQUENCY OF INJURED/UNINJURED CHILDREN (1-4) IN PASSENGER CAR ACCIDENTS

Restraint Usage	Idaho		New Jersey		New York 1974		New York 1977	
	Uninjured	Injured	Uninjured	Injured	Uninjured	Injured	Uninjured	Injured
Child Restraint	84.1 %	15.9 %	73.0 %	27.0 %	80.2 %	19.8 %	78.9 %	21.1 %
Seat Belt	89.5	10.5	82.3	17.7	77.7	22.3	81.4	18.6
No Restraint	81.7	18.3	66.2	33.8	69.3	30.7	70.4	29.6
No. of Cases	3,766		6,738		10,745		11,092	
x^2/d.f./p	12.9/2 d.f./p=0.002		100.8/2 d.f./p=0.000		75.6/2 d.f./p=0.000		91.6/2 d.f./p=0.000	

9.0 INJURED/UNINJURED FREQUENCIES, BY AGE

The distribution of injury by age in Idaho and New Jersey is essentially uniform, i.e., being injured or not injured is independent of age. This is not the case in New York where one year-old children have the lowest injury rate and four year-old children have the highest rate. It should be noted, however, that the one-year-old age category in New York also includes infants.

TABLE 9

FREQUENCY OF INJURED/UNINJURED CHILDREN, BY AGE, IN PASSENGER CAR ACCIDENTS

Child's Age	Idaho		New Jersey		New York 1974		New York 1977	
	Uninjured	Injured	Uninjured	Injured	Uninjured	Injured	Uninjured	Injured
One	82.5 %	17.5 %	68.6 %	31.4 %	75.4 %	24.6 %	75.0 %	25.0 %
Two	84.3	15.7	68.9	31.1	70.5	29.5	71.3	28.7
Three	81.1	18.9	70.3	29.7	71.2	28.8	72.0	28.0
Four	81.4	18.6	68.4	31.6	67.6	32.4	71.0	29.0
No. of Cases	3,766		6,738		10,745		11,092	
x^2/d.f./p	4.2/3 d.f./p=0.24		1.8/3 d.f./p=0.61		40.7/3 d.f./p=0.000		15.0/3 d.f./p=0.002	

10.0 INJURED/UNINJURED FREQUENCIES, BY FRONT/REAR SEAT

The rear seat is 25 to 30 percent safer than the front seat. The benefits of placing unrestrained children in the rear seat, in other words, are about the same as placing them in a child restraint in the front seat.

TABLE 10

FREQUENCY OF INJURED/UNINJURED CHILDREN (1-4), BY FRONT/REAR SEAT, IN PASSENGER CAR ACCIDENTS

Seat Position	Idaho		New Jersey		New York 1974		New York 1977	
	Uninjured	Injured	Uninjured	Injured	Uninjured	Injured	Uninjured	Injured
Front	79.3 %	20.7 %	63.9 %	36.1 %	66.9 %	33.1 %	68.2 %	31.8 %
Rear	87.3	12.7	75.0	25.0	75.3	24.7	76.7	23.3
No. of Cases	3,766		6,738		10,745		11,092	
x^2/d.f./p	39.6/1 d.f./p=0.0		96.6/1 d.f./p=0.0		93.4/1 d.f./p=0.0		100.0/1 d.f./p=0.0	

11.0 INJURY LEVEL FREQUENCIES, BY RESTRAINT USAGE

Restrained children are less likely to be injured or killed than unrestrained children. In terms of reducing fatalities, child restraints and seat belts appear to be equally effective. However, compared to child restraint usage, seat belts account for a greater reduction in child injury rates for Type A, Type B and (with the exception of New York 1974) Type C injuries. This latter finding might be attributed to the fact that child restraints are often misused.

TABLE 11

FREQUENCY OF INJURY LEVELS FOR RESTRAINED/UNRESTRAINED CHILDREN (1-4) IN PASSENGER CAR ACCIDENTS

Restraint Usage	Idaho (%)					New Jersey (%)					New York 1974 (%)					New York 1977 (%)				
	O	C	B	A	K	O	C	B	A	K	O	C	B	A	K	O	C	B	A	K
Child Restraint	84.1	4.1	9.7	2.1	0.0	73.0	16.7	9.5	0.8	0.0	80.6	4.9	12.1	2.3	0.1	78.9	8.1	11.5	1.5	0.0
Seat Belt	89.5	3.3	6.0	1.2	0.0	82.3	12.8	4.3	0.6	0.0	78.0	9.6	10.7	1.6	0.1	81.4	8.1	9.6	1.0	0.0
No Restraint	81.7	6.0	10.2	2.0	0.2	66.2	21.2	11.7	0.8	0.06	69.5	11.1	16.3	3.0	0.1	70.4	11.4	15.6	2.4	0.1
No. of Cases	3,766					6,738					10,702					11,092				
x^2/d.f./p	13.9/8 d.f./p=0.08					106.3/8 d.f./p=0.000					88.0/8 d.f./p=0.000					96.1/8 d.f./p=0.000				

12.0 RESTRAINT USAGE, BY AGE

Parents who restrain accident-involved children tend to put one-year-olds in child restraints, while shifting to seat belts for two, three and four-year-old children.

TABLE 12

FREQUENCY OF USE OF CHILD RESTRAINTS AND SEAT BELTS
BY AGE OF CHILDREN IN PASSENGER CAR ACCIDENTS

Restraint Usage	Idaho (%)					New Jersey (%)					New York 1974 (%)					New York 1977 (%)				
	Total Usage	Usage by Age (year)				Total Usage	Usage by Age (year)				Total Usage	Usage by Age (year)				Total Usage	Usage by Age Year			
		1	2	3	4		1	2	3	4		1	2	3	4		1	2	3	4
Child Restraint	3.8	65.5	21.4	9.0	4.1	9.4	63.2	25.0	7.4	4.4	7.4	61.2	23.4	10.7	4.7	8.8	68.1	21.5	6.3	4.1
Seat Belt	8.8	37.3	28.0	18.4	16.3	13.8	25.6	25.8	23.4	25.2	13.1	26.3	23.0	25.8	24.9	12.0	32.7	23.7	22.8	20.8
No Restraint	87.9	27.1	26.9	23.6	22.3	76.8	21.2	22.6	27.9	28.2	79.5	21.5	23.7	27.5	27.2	79.2	24.6	24.3	25.7	25.4
No. of Cases	3,766					6,738					10,745					11,092				
χ^2/d.f./p	120.7/6 d.f./p=0.000					609.7/6 d.f./p=0.000					681.3/6 d.f./p=0.000					893.3/6 d.f./p=0.000				

*In New York (and possibly Idaho), the one-year-old category includes infants.

13.0 RESTRAINT USAGE, BY FRONT/REAR SEAT

The percentages of restrained children occupying the front and rear seats are approximately equal. This also holds true when considering children in seat belts and child restraints separately.

TABLE 13

FREQUENCY OF USE OF CHILD RESTRAINTS AND SEAT BELTS
BY CHILDREN (1-4) IN FRONT/REAR SEATS IN PASSENGER CAR ACCIDENTS

Restraint Usage	Idaho		New Jersey		New York 1974		New York 1977	
	Front Seat	Rear Seat	Front Seat	Rear Seat	Front Seat	Rear Seat	Front Seat	Rear Seat
Child Restraint	3.4 %	4.5 %	9.0 %	9.8 %	7.1 %	7.7 %	7.7 %	9.9 %
Seat Belt	8.8	8.8	14.9	12.6	13.0	13.2	11.5	12.5
No Restraint	87.8	86.7	76.1	77.6	79.9	79.1	80.8	77.6
No. of Cases	3,766		6,738		10,745		11,092	
χ^2/d.f./p	3.02/2 d.f./p=0.22		7.8/2 d.f./p=0.02		1.69/2 d.f./p=0.43		20.7/2 d.f./p=0.00	

14.0 AGE FREQUENCIES, BY FRONT/REAR SEAT

As age increases, the position of the child-passenger shifts from the front to rear seat. The shift is most pronounced between ages one* and two.

TABLE 14

FREQUENCY OF AGE OF CHILDREN (1-4) IN FRONT/REAR SEATS IN PASSENGER CAR ACCIDENTS

Child Age	Idaho		New Jersey		New York 1974		New York 1977	
	Front Seat	Rear Seat	Front Seat	Rear Seat	Front Seat	Rear Seat	Front Seat	Rear Seat
One	77.3 %	22.7 %	70.5 %	29.5 %	64.5 %	35.5 %	63.8 %	36.2 %
Two	58.9	41.1	54.9	45.1	51.2	48.8	50.7	49.3
Three	53.2	46.8	47.3	52.7	42.8	57.2	43.7	56.3
Four	47.8	52.1	41.2	58.8	39.0	61.0	38.6	61.4
No. of Cases	3,766		6,738		10,745		11,092	
x^2/d.f./p	205.4/3 d.f./p=0.000		335.2/3 d.f./p=0.000		416.5/3 d.f./p=0.000		421.7/3 d.f./p=0.000	

*In New York (and possibly Idaho), the one-year-old category includes infants.

APPENDIX B

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

TABLE B-1

FULLY CROSS-CLASSIFIED TABLE OF NEW YORK 1974
RAW DATA FOR KA/BCO INJURY DICHOTOMY

DAMAGE X	WEIGHT W	OCCAGE O	RDCLASS C	RESTRAINT R	KAXBCO (I) K+A	B+C+O
NONELITE	LT 3000	1 YEAR	STATEHWY	NONE	3	39
				SEATBELT	0	14
				CH. REST	0	16
			COUNTYRD	NONE	1	26
				SEATBELT	0	12
				CH. REST	0	6
			CITY STR	NONE	0	54
				SEATBELT	0	7
				CH. REST	0	6
			INTERST	NONE	0	9
				SEATBELT	0	4
				CH. REST	0	2
		2 YEARS	STATEHWY	NONE	0	56
				SEATBELT	0	10
				CH. REST	0	7
			COUNTYRD	NONE	0	49
				SEATBELT	0	8
				CH. REST	0	5
			CITY STR	NONE	0	53
				SEATBELT	0	10
				CH. REST	0	0
			INTERST	NONE	0	5
				SEATBELT	0	1
				CH. REST	0	1
		3 YEARS	STATEHWY	NONE	2	60
				SEATBELT	0	7
				CH. REST	0	3
			COUNTYRD	NONE	3	32
				SEATBELT	0	7
				CH. REST	0	3
			CITY STR	NONE	1	40
				SEATBELT	1	8
				CH. REST	0	1
			INTERST	NONE	0	10
				SEATBELT	0	2
				CH. REST	0	1
		4 YEARS	STATEHWY	NONE	0	56
				SEATBELT	2	4
				CH. REST	0	0
			COUNTYRD	NONE	2	39
				SEATBELT	0	7
				CH. REST	0	0
			CITY STR	NONE	0	38
				SEATBELT	0	9
				CH. REST	0	2
			INTERST	NONE	0	10
				SEATBELT	0	4
				CH. REST	0	0

TABLE B-1 (continued)

30003599	1 YEAR	STATEHWY	NONE	I	2	44
			SEATBELT	I	0	10
			CH, REST	I	0	17
		COUNTYRD	NONE	I	1	35
			SEATBELT	I	0	8
			CH, REST	I	0	11
		CITY STR	NONE	I	2	44
			SEATBELT	I	0	5
			CH, REST	I	0	7
		INTERST	NONE	I	0	4
			SEATBELT	I	0	1
			CH, REST	I	0	3
	2 YEARS	STATEHWY	NONE	I	1	47
			SEATBELT	I	0	8
			CH, REST	I	0	6
		COUNTYRD	NONE	I	0	44
			SEATBELT	I	0	4
			CH, REST	I	0	7
		CITY STR	NONE	I	0	49
			SEATBELT	I	0	4
			CH, REST	I	0	1
		INTERST	NONE	I	0	8
			SEATBELT	I	0	1
			CH, REST	I	0	2
	3 YEARS	STATEHWY	NONE	I	0	61
			SEATBELT	I	0	8
			CH, REST	I	0	4
		COUNTYRD	NONE	I	0	64
			SEATBELT	I	0	6
			CH, REST	I	0	2
		CITY STR	NONE	I	1	54
			SEATBELT	I	0	7
			CH, REST	I	0	1
		INTERST	NONE	I	0	4
			SEATBELT	I	0	1
			CH, REST	I	0	0
	4 YEARS	STATEHWY	NONE	I	2	67
			SEATBELT	I	0	9
			CH, REST	I	0	2
		COUNTYRD	NONE	I	0	48
			SEATBELT	I	0	5
			CH, REST	I	0	0
		CITY STR	NONE	I	2	35
			SEATBELT	I	0	2
			CH, REST	I	0	0
		INTERST	NONE	I	0	5
			SEATBELT	I	0	3
			CH, REST	I	0	1

TABLE B-1 (continued)

3600 +	1 YEAR	STATEHWY	NONE	2	90
			SEATBELT	0	18
			CH. REST	1	33
		COUNTYRD	NONE	0	57
			SEATBELT	0	12
			CH. REST	0	21
		CITY STR	NONE	1	65
			SEATBELT	0	15
			CH. REST	0	15
		INTERST	NONE	1	8
			SEATBELT	0	4
			CH. REST	0	2
	2 YEARS	STATEHWY	NONE	2	96
			SEATBELT	0	20
			CH. REST	0	14
		COUNTYRD	NONE	2	90
			SEATBELT	0	14
			CH. REST	0	7
		CITY STR	NONE	5	84
			SEATBELT	0	12
			CH. REST	0	3
		INTERST	NONE	1	14
			SEATBELT	0	2
			CH. REST	0	1
	3 YEARS	STATEHWY	NONE	2	123
			SEATBELT	0	18
			CH. REST	0	4
		COUNTYRD	NONE	2	87
			SEATBELT	0	17
			CH. REST	0	5
		CITY STR	NONE	2	82
			SEATBELT	0	7
			CH. REST	0	5
		INTERST	NONE	0	13
			SEATBELT	0	3
			CH. REST	0	1
	4 YEARS	STATEHWY	NONE	0	102
			SEATBELT	1	21
			CH. REST	0	2
		COUNTYRD	NONE	1	128
			SEATBELT	0	20
			CH. REST	0	1
		CITY STR	NONE	1	89
			SEATBELT	0	10
			CH. REST	0	0
		INTERST	NONE	0	19
			SEATBELT	0	0
			CH. REST	0	1

TABLE B-1 (continued)

MODERATE LT 3000	1 YEAR	STATEHWY	NONE	3	87
			SEATBELT	0	20
			CH. REST	0	30
		COUNTYRD	NONE	3	56
			SEATBELT	1	13
			CH. REST	0	18
		CITY STR	NONE	1	68
			SEATBELT	1	16
			CH. REST	2	18
		INTERST	NONE	1	21
			SEATBELT	0	2
			CH. REST	0	5
	2 YEARS	STATEHWY	NONE	5	68
			SEATBELT	0	13
			CH. REST	0	12
		COUNTYRD	NONE	3	56
			SEATBELT	0	21
			CH. REST	0	5
		CITY STR	NONE	3	71
			SEATBELT	0	11
			CH. REST	0	3
		INTERST	NONE	0	20
			SEATBELT	0	7
			CH. REST	0	2
	3 YEARS	STATEHWY	NONE	1	112
			SEATBELT	1	17
			CH. REST	0	3
		COUNTYRD	NONE	4	67
			SEATBELT	0	21
			CH. REST	1	3
		CITY STR	NONE	7	82
			SEATBELT	0	11
			CH. REST	0	3
		INTERST	NONE	1	20
			SEATBELT	0	7
			CH. REST	0	0
	4 YEARS	STATEHWY	NONE	5	110
			SEATBELT	1	22
			CH. REST	0	1
		COUNTYRD	NONE	0	77
			SEATBELT	0	7
			CH. REST	0	4
		CITY STR	NONE	0	90
			SEATBELT	0	6
			CH. REST	0	0
		INTERST	NONE	0	18
			SEATBELT	0	3
			CH. REST	0	0

TABLE B-1 (continued)

30003599	1 YEAR	STATEHWY	NONE	3	78
			SEATBELT	0	12
			CH, REST	0	24
		COUNTYRD	NONE	3	61
			SEATBELT	0	12
			CH, REST	1	24
		CITY STR	NONE	3	61
			SEATBELT	0	9
			CH, REST	2	11
		INTERST	NONE	0	17
			SEATBELT	0	4
			CH, REST	0	3
	2 YEARS	STATEHWY	NONE	2	77
			SEATBELT	1	17
			CH, REST	0	10
		COUNTYRD	NONE	1	74
			SEATBELT	0	11
			CH, REST	0	6
		CITY STR	NONE	4	80
			SEATBELT	0	12
			CH, REST	0	8
		INTERST	NONE	0	21
			SEATBELT	0	3
			CH, REST	0	0
	3 YEARS	STATEHWY	NONE	4	110
			SEATBELT	1	16
			CH, REST	0	5
		COUNTYRD	NONE	3	75
			SEATBELT	0	11
			CH, REST	0	3
		CITY STR	NONE	5	84
			SEATBELT	3	7
			CH, REST	0	3
		INTERST	NONE	1	16
			SEATBELT	0	3
			CH, REST	0	1
	4 YEARS	STATEHWY	NONE	2	85
			SEATBELT	0	15
			CH, REST	0	3
		COUNTYRD	NONE	2	61
			SEATBELT	0	11
			CH, REST	0	0
		CITY STR	NONE	2	83
			SEATBELT	1	11
			CH, REST	0	1
		INTERST	NONE	0	25
			SEATBELT	0	2
			CH, REST	0	1

TABLE B-1 (continued)

3600 +	1 YEAR	STATEHWY	NONE	I	1	122
			SEATBELT	I	0	37
			CH, REST	I	2	38
		COUNTYRD	NONE	I	2	80
			SEATBELT	I	0	13
			CH, REST	I	0	28
		CITY STR	NONE	I	4	132
			SEATBELT	I	0	18
			CH, REST	I	0	13
		INTERST	NONE	I	1	22
			SEATBELT	I	0	4
			CH, REST	I	0	3
	2 YEARS	STATEHWY	NONE	I	1	133
			SEATBELT	I	0	24
			CH, REST	I	0	20
		COUNTYRD	NONE	I	6	100
			SEATBELT	I	0	23
			CH, REST	I	0	13
		CITY STR	NONE	I	2	140
			SEATBELT	I	0	13
			CH, REST	I	1	7
		INTERST	NONE	I	1	24
			SEATBELT	I	0	8
			CH, REST	I	0	3
	3 YEARS	STATEHWY	NONE	I	7	190
			SEATBELT	I	0	26
			CH, REST	I	0	7
		COUNTYRD	NONE	I	3	122
			SEATBELT	I	0	19
			CH, REST	I	0	4
		CITY STR	NONE	I	2	152
			SEATBELT	I	1	25
			CH, REST	I	0	4
		INTERST	NONE	I	1	30
			SEATBELT	I	1	7
			CH, REST	I	0	1
	4 YEARS	STATEHWY	NONE	I	4	191
			SEATBELT	I	0	31
			CH, REST	I	0	1
		COUNTYRD	NONE	I	0	122
			SEATBELT	I	0	28
			CH, REST	I	0	4
		CITY STR	NONE	I	6	164
			SEATBELT	I	1	18
			CH, REST	I	0	2
		INTERST	NONE	I	0	28
			SEATBELT	I	0	9
			CH, REST	I	0	0

TABLE B-1 (continued)

SEVERE	LT 3000	1 YEAR	STATEHWY	NONE	1	21
				SEATBELT	0	5
				CH. REST	0	12
			COUNTYRD	NONE	1	24
				SEATBELT	0	2
				CH. REST	0	10
			CITY STR	NONE	2	16
				SEATBELT	0	4
				CH. REST	1	3
			INTERST	NONE	2	4
				SEATBELT	0	2
				CH. REST	0	0
		2 YEARS	STATEHWY	NONE	1	36
				SEATBELT	0	5
				CH. REST	1	2
			COUNTYRD	NONE	1	25
				SEATBELT	0	4
				CH. REST	0	5
			CITY STR	NONE	0	13
				SEATBELT	0	1
				CH. REST	0	1
			INTERST	NONE	0	8
				SEATBELT	0	1
				CH. REST	0	2
		3 YEARS	STATEHWY	NONE	1	34
				SEATBELT	0	0
				CH. REST	0	2
			COUNTYRD	NONE	1	26
				SEATBELT	0	9
				CH. REST	0	1
			CITY STR	NONE	3	20
				SEATBELT	0	3
				CH. REST	0	2
			INTERST	NONE	3	5
				SEATBELT	0	1
				CH. REST	0	0
		4 YEARS	STATEHWY	NONE	2	23
				SEATBELT	0	4
				CH. REST	0	2
			COUNTYRD	NONE	4	26
				SEATBELT	0	6
				CH. REST	0	0
			CITY STR	NONE	0	14
				SEATBELT	0	2
				CH. REST	0	0
			INTERST	NONE	1	5
				SEATBELT	0	2
				CH. REST	0	0

TABLE B-1 (continued)

30003599	1 YEAR	STATEHWY	NONE	3	23
			SEATBELT	0	5
			CH. REST	1	4
		COUNTYRD	NONE	0	17
			SEATBELT	0	2
			CH. REST	0	5
		CITY STR	NONE	0	14
			SEATBELT	0	4
			CH. REST	0	3
		INTERST	NONE	2	3
			SEATBELT	0	0
			CH. REST	0	2
	2 YEARS	STATEHWY	NONE	2	30
			SEATBELT	0	4
			CH. REST	0	1
		COUNTYRD	NONE	1	20
			SEATBELT	0	2
			CH. REST	0	1
		CITY STR	NONE	3	11
			SEATBELT	0	3
			CH. REST	1	0
		INTERST	NONE	1	6
			SEATBELT	0	1
			CH. REST	0	0
	3 YEARS	STATEHWY	NONE	1	24
			SEATBELT	0	2
			CH. REST	0	2
		COUNTYRD	NONE	2	15
			SEATBELT	0	0
			CH. REST	0	2
		CITY STR	NONE	2	7
			SEATBELT	0	3
			CH. REST	0	0
		INTERST	NONE	1	3
			SEATBELT	0	0
			CH. REST	0	0
	4 YEARS	STATEHWY	NONE	2	28
			SEATBELT	0	2
			CH. REST	0	1
		COUNTYRD	NONE	1	14
			SEATBELT	0	0
			CH. REST	0	0
		CITY STR	NONE	1	13
			SEATBELT	0	1
			CH. REST	0	0
		INTERST	NONE	0	4
			SEATBELT	0	0
			CH. REST	0	0

TABLE B-1 (concluded)

3600 *	1 YEAR	STATEHWY	NONE	3	28
			SEATBELT	0	6
			CH. REST	1	4
		COUNTYRD	NONE	2	21
			SEATBELT	0	2
			CH. REST	0	3
		CITY STR	NONE	0	17
			SEATBELT	0	4
			CH. REST	2	6
		INTERST	NONE	1	3
			SEATBELT	0	1
			CH. REST	0	2
	2 YEARS	STATEHWY	NONE	1	21
			SEATBELT	0	7
			CH. REST	0	5
		COUNTYRD	NONE	2	17
			SEATBELT	1	3
			CH. REST	0	2
		CITY STR	NONE	0	17
			SEATBELT	0	1
			CH. REST	0	1
		INTERST	NONE	1	7
			SEATBELT	0	0
			CH. REST	0	0
	3 YEARS	STATEHWY	NONE	2	33
			SEATBELT	0	5
			CH. REST	0	2
		COUNTYRD	NONE	1	30
			SEATBELT	0	6
			CH. REST	0	1
		CITY STR	NONE	0	27
			SEATBELT	0	4
			CH. REST	0	0
		INTERST	NONE	1	4
			SEATBELT	0	3
			CH. REST	0	0
	4 YEARS	STATEHWY	NONE	2	50
			SEATBELT	2	4
			CH. REST	0	0
		COUNTYRD	NONE	4	22
			SEATBELT	0	5
			CH. REST	0	1
		CITY STR	NONE	2	22
			SEATBELT	0	3
			CH. REST	0	0
		INTERST	NONE	2	9
			SEATBELT	0	1
			CH. REST	0	0

THE TOTAL FREQUENCY IS 9103

TABLE B-2

FULLY CROSS-CLASSIFIED TABLE OF NEW YORK 1974
RAW DATA FOR KAB/CO INJURY DICHOTOMY

DAMAGE X	WEIGHT W	OCCAGE O	RDCLASS C	RESTRAINT R	KABXCO (I) K+A+B	+O
NONELITE	LT 3000	1 YEAR	STATEHWY	NONE	8	34
				SEATBELT	3	11
				CH, REST	1	15
			COUNTYRD	NONE	4	23
				SEATBELT	1	11
				CH, REST	0	6
			CITY STR	NONE	7	47
				SEATBELT	0	7
				CH, REST	0	6
			INTERST	NONE	1	8
				SEATBELT	1	3
				CH, REST	0	2
		2 YEARS	STATEHWY	NONE	8	48
				SEATBELT	2	8
				CH, REST	0	7
			COUNTYRD	NONE	8	41
				SEATBELT	0	8
				CH, REST	0	5
			CITY STR	NONE	9	44
				SEATBELT	1	9
				CH, REST	0	0
			INTERST	NONE	1	4
				SEATBELT	1	0
				CH, REST	0	1
		3 YEARS	STATEHWY	NONE	7	55
				SEATBELT	1	6
				CH, REST	0	3
			COUNTYRD	NONE	6	29
				SEATBELT	1	6
				CH, REST	0	3
			CITY STR	NONE	5	36
				SEATBELT	1	8
				CH, REST	0	1
			INTERST	NONE	1	9
				SEATBELT	1	1
				CH, REST	0	1
		4 YEARS	STATEHWY	NONE	11	45
				SEATBELT	3	3
				CH, REST	0	0
			COUNTYRD	NONE	4	37
				SEATBELT	0	7
				CH, REST	0	0
			CITY STR	NONE	12	26
				SEATBELT	2	7
				CH, REST	0	2
			INTERST	NONE	3	7
				SEATBELT	1	3
				CH, REST	0	0

TABLE B-2 (continued)

30003599	1 YEAR	STATEHWY	NONE	7	39
			SEATBELT	0	10
			CH, REST	0	17
		COUNTYRD	NONE	5	31
			SEATBELT	0	8
			CH, REST	0	11
		CITY STR	NONE	7	39
			SEATBELT	0	5
			CH, REST	0	7
		INTERST	NONE	1	3
			SEATBELT	0	1
			CH, REST	0	3
	2 YEARS	STATEHWY	NONE	8	40
			SEATBELT	1	7
			CH, REST	0	6
		COUNTYRD	NONE	6	38
			SEATBELT	0	4
			CH, REST	1	6
		CITY STR	NONE	3	46
			SEATBELT	0	4
			CH, REST	0	1
		INTERST	NONE	1	7
			SEATBELT	0	1
			CH, REST	0	2
	3 YEARS	STATEHWY	NONE	9	52
			SEATBELT	0	8
			CH, REST	0	4
		COUNTYRD	NONE	6	58
			SEATBELT	1	5
			CH, REST	0	2
		CITY STR	NONE	8	47
			SEATBELT	0	7
			CH, REST	0	1
		INTERST	NONE	0	4
			SEATBELT	0	1
			CH, REST	0	0
	4 YEARS	STATEHWY	NONE	9	60
			SEATBELT	0	9
			CH, REST	1	1
		COUNTYRD	NONE	8	40
			SEATBELT	0	5
			CH, REST	0	0
		CITY STR	NONE	6	31
			SEATBELT	0	2
			CH, REST	0	0
		INTERST	NONE	1	4
			SEATBELT	0	3
			CH, REST	1	0

TABLE B-2 (continued)

3600 +	1 YEAR	STATEHWY	NONE	10	82
			SEATBELT	1	17
			CH, REST	1	33
		COUNTYRD	NONE	5	52
			SEATBELT	1	11
			CH, REST	0	21
		CITY STR	NONE	9	57
			SEATBELT	1	14
			CH, REST	2	13
		INTERST	NONE	1	8
			SEATBELT	1	3
			CH, REST	0	2
	2 YEARS	STATEHWY	NONE	10	88
			SEATBELT	0	20
			CH, REST	0	14
		COUNTYRD	NONE	11	81
			SEATBELT	0	14
			CH, REST	1	6
		CITY STR	NONE	13	76
			SEATBELT	0	12
			CH, REST	2	1
		INTERST	NONE	3	12
			SEATBELT	0	2
			CH, REST	0	1
	3 YEARS	STATEHWY	NONE	11	114
			SEATBELT	1	17
			CH, REST	0	4
		COUNTYRD	NONE	5	84
			SEATBELT	1	16
			CH, REST	1	4
		CITY STR	NONE	8	76
			SEATBELT	2	5
			CH, REST	2	3
		INTERST	NONE	0	13
			SEATBELT	0	3
			CH, REST	0	1
	4 YEARS	STATEHWY	NONE	14	88
			SEATBELT	3	19
			CH, REST	0	2
		COUNTYRD	NONE	14	115
			SEATBELT	1	19
			CH, REST	0	1
		CITY STR	NONE	14	76
			SEATBELT	0	10
			CH, REST	0	0
		INTERST	NONE	2	17
			SEATBELT	0	0
			CH, REST	0	1

TABLE B-2 (continued)

MODERATE LT 3000	1 YEAR	STATEHWY	NONE	9	81
			SEATBELT	0	20
			CH, REST	5	25
		COUNTYRD	NONE	9	50
			SEATBELT	1	13
			CH, REST	2	16
		CITY STR	NONE	12	57
			SEATBELT	1	16
			CH, REST	4	16
		INTERST	NONE	9	13
			SEATBELT	1	1
			CH, REST	0	5
	2 YEARS	STATEHWY	NONE	25	48
			SEATBELT	1	12
			CH, REST	5	7
		COUNTYRD	NONE	15	44
			SEATBELT	4	17
			CH, REST	1	4
		CITY STR	NONE	22	52
			SEATBELT	4	7
			CH, REST	0	3
		INTERST	NONE	1	19
			SEATBELT	0	7
			CH, REST	0	2
	3 YEARS	STATEHWY	NONE	18	95
			SEATBELT	4	14
			CH, REST	1	2
		COUNTYRD	NONE	7	64
			SEATBELT	1	20
			CH, REST	2	2
		CITY STR	NONE	28	61
			SEATBELT	4	7
			CH, REST	0	3
		INTERST	NONE	4	17
			SEATBELT	1	6
			CH, REST	0	0
	4 YEARS	STATEHWY	NONE	26	89
			SEATBELT	1	22
			CH, REST	0	1
		COUNTYRD	NONE	17	60
			SEATBELT	2	5
			CH, REST	0	4
		CITY STR	NONE	19	71
			SEATBELT	2	4
			CH, REST	0	0
		INTERST	NONE	5	13
			SEATBELT	1	2
			CH, REST	0	0

TABLE B-2 (continued)

30003599	1 YEAR	STATEHWY	NONE	16	65
			SEATBELT	2	10
			CH, REST	5	19
		COUNTYRD	NONE	10	54
			SEATBELT	1	11
			CH, REST	5	20
		CITY STR	NONE	8	56
			SEATBELT	0	9
			CH, REST	3	10
		INTERST	NONE	1	16
			SEATBELT	1	3
			CH, REST	0	3
	2 YEARS	STATEHWY	NONE	14	65
			SEATBELT	2	16
			CH, REST	0	10
		COUNTYRD	NONE	14	61
			SEATBELT	1	10
			CH, REST	1	5
		CITY STR	NONE	19	65
			SEATBELT	3	9
			CH, REST	0	8
		INTERST	NONE	3	18
			SEATBELT	1	2
			CH, REST	0	0
	3 YEARS	STATEHWY	NONE	25	89
			SEATBELT	2	15
			CH, REST	0	5
		COUNTYRD	NONE	12	66
			SEATBELT	1	10
			CH, REST	1	2
		CITY STR	NONE	18	71
			SEATBELT	3	7
			CH, REST	0	3
		INTERST	NONE	3	14
			SEATBELT	0	3
			CH, REST	0	1
	4 YEARS	STATEHWY	NONE	11	76
			SEATBELT	1	14
			CH, REST	0	3
		COUNTYRD	NONE	12	51
			SEATBELT	2	9
			CH, REST	0	0
		CITY STR	NONE	25	60
			SEATBELT	2	10
			CH, REST	0	1
		INTERST	NONE	4	21
			SEATBELT	1	1
			CH, REST	1	0

TABLE B-2 (continued)

3600 +	1 YEAR	STATEHWY	NONE	14	109
			SEATBELT	3	34
			CH. REST	5	35
		COUNTYRD	NONE	16	66
			SEATBELT	1	12
			CH. REST	1	27
		CITY STR	NONE	21	115
			SEATBELT	4	14
			CH. REST	2	11
		INTERST	NONE	6	17
			SEATBELT	0	4
			CH. REST	1	2
	2 YEARS	STATEHWY	NONE	17	117
			SEATBELT	0	24
			CH. REST	0	20
		COUNTYRD	NONE	21	85
			SEATBELT	3	20
			CH. REST	0	13
		CITY STR	NONE	41	101
			SEATBELT	2	11
			CH. REST	3	5
		INTERST	NONE	4	21
			SEATBELT	0	8
			CH. REST	0	3
	3 YEARS	STATEHWY	NONE	34	163
			SEATBELT	1	25
			CH. REST	0	7
		COUNTYRD	NONE	23	102
			SEATBELT	2	17
			CH. REST	1	3
		CITY STR	NONE	36	118
			SEATBELT	4	22
			CH. REST	0	4
		INTERST	NONE	2	29
			SEATBELT	2	6
			CH. REST	0	1
	4 YEARS	STATEHWY	NONE	33	162
			SEATBELT	2	29
			CH. REST	1	0
		COUNTYRD	NONE	21	101
			SEATBELT	2	26
			CH. REST	0	4
		CITY STR	NONE	42	128
			SEATBELT	4	15
			CH. REST	0	2
		INTERST	NONE	6	22
			SEATBELT	2	7
			CH. REST	0	0

TABLE B-2 (continued)

SEVERE	LT 3000	1 YEAR	STATEHWY	NONE	I	11	11
				SEATBELT	I	2	3
				CH. REST	I	5	7
			COUNTYRD	NONE	I	12	13
				SEATBELT	I	2	0
				CH. REST	I	5	5
			CITY STR	NONE	I	6	12
				SEATBELT	I	1	3
				CH. REST	I	3	1
			INTERST	NONE	I	4	2
				SEATBELT	I	1	1
				CH. REST	I	0	0
		2 YEARS	STATEHWY	NONE	I	16	21
				SEATBELT	I	1	4
				CH. REST	I	2	1
			COUNTYRD	NONE	I	11	15
				SEATBELT	I	2	2
				CH. REST	I	3	2
			CITY STR	NONE	I	2	11
				SEATBELT	I	0	1
				CH. REST	I	0	1
			INTERST	NONE	I	3	5
				SEATBELT	I	0	1
				CH. REST	I	0	2
		3 YEARS	STATEHWY	NONE	I	11	24
				SEATBELT	I	0	0
				CH. REST	I	0	2
			COUNTYRD	NONE	I	11	16
				SEATBELT	I	3	6
				CH. REST	I	0	1
			CITY STR	NONE	I	7	16
				SEATBELT	I	1	2
				CH. REST	I	0	2
			INTERST	NONE	I	3	5
				SEATBELT	I	0	1
				CH. REST	I	0	0
		4 YEARS	STATEHWY	NONE	I	11	14
				SEATBELT	I	1	3
				CH. REST	I	1	1
			COUNTYRD	NONE	I	15	15
				SEATBELT	I	1	5
				CH. REST	I	0	0
			CITY STR	NONE	I	7	7
				SEATBELT	I	1	1
				CH. REST	I	0	0
			INTERST	NONE	I	3	3
				SEATBELT	I	0	2
				CH. REST	I	0	0

TABLE B-2 (continued)

30003599	1 YEAR	STATEHWY	NONE	6	20
			SEATBELT	0	5
			CH, REST	3	2
		COUNTYRD	NONE	8	9
			SEATBELT	0	2
			CH, REST	1	4
		CITY STR	NONE	3	11
			SEATBELT	1	3
			CH, REST	2	1
		INTERST	NONE	2	3
			SEATBELT	0	0
			CH, REST	0	2
	2 YEARS	STATEHWY	NONE	14	18
			SEATBELT	2	2
			CH, REST	0	1
		COUNTYRD	NONE	7	14
			SEATBELT	0	2
			CH, REST	0	1
		CITY STR	NONE	8	6
			SEATBELT	1	2
			CH, REST	1	0
		INTERST	NONE	2	5
			SEATBELT	1	0
			CH, REST	0	0
	3 YEARS	STATEHWY	NONE	4	21
			SEATBELT	0	2
			CH, REST	0	2
		COUNTYRD	NONE	9	8
			SEATBELT	0	0
			CH, REST	0	2
		CITY STR	NONE	4	5
			SEATBELT	1	2
			CH, REST	0	0
		INTERST	NONE	1	3
			SEATBELT	0	0
			CH, REST	0	0
	4 YEARS	STATEHWY	NONE	7	23
			SEATBELT	0	2
			CH, REST	0	1
		COUNTYRD	NONE	5	10
			SEATBELT	0	0
			CH, REST	0	0
		CITY STR	NONE	7	7
			SEATBELT	0	1
			CH, REST	0	0
		INTERST	NONE	3	1
			SEATBELT	0	0
			CH, REST	0	0

TABLE B-2 (concluded)

3600 +	1 YEAR	STATEHWY	NONE	10	21
			SEATBELT	1	5
			CH, REST	3	2
		COUNTYRD	NONE	4	19
			SEATBELT	1	1
			CH, REST	2	1
		CITY STR	NONE	5	12
			SEATBELT	2	2
			CH, REST	3	5
		INTERST	NONE	1	3
			SEATBELT	0	1
			CH, REST	0	2
	2 YEARS	STATEHWY	NONE	6	16
			SEATBELT	1	6
			CH, REST	3	2
		COUNTYRD	NONE	7	12
			SEATBELT	1	3
			CH, REST	0	2
		CITY STR	NONE	6	11
			SEATBELT	1	0
			CH, REST	1	0
		INTERST	NONE	1	7
			SEATBELT	0	0
			CH, REST	0	0
	3 YEARS	STATEHWY	NONE	7	28
			SEATBELT	0	5
			CH, REST	1	1
		COUNTYRD	NONE	8	23
			SEATBELT	1	5
			CH, REST	1	0
		CITY STR	NONE	6	21
			SEATBELT	3	1
			CH, REST	0	0
		INTERST	NONE	4	1
			SEATBELT	2	1
			CH, REST	0	0
	4 YEARS	STATEHWY	NONE	10	42
			SEATBELT	2	4
			CH, REST	0	0
		COUNTYRD	NONE	11	15
			SEATBELT	2	3
			CH, REST	0	1
		CITY STR	NONE	6	18
			SEATBELT	0	3
			CH, REST	0	0
		INTERST	NONE	4	7
			SEATBELT	0	1
			CH, REST	0	0

THE TOTAL FREQUENCY IS 9103

TABLE B-3

FULLY CROSS-CLASSIFIED TABLE OF NEW YORK 1974
RAW DATA FOR KABC/O INJURY DICHOTOMY

DAMAGE X	WEIGHT W	OCCAGE O	RDCLASS C	RESTRAINT R	KABCXO (I) K+A+B+C	O
NONELITE	LT 3000	1 YEAR	STATEHWY	NONE	10	32
				SEATBELT	3	11
				CH, REST	1	15
			COUNTYRD	NONE	4	23
				SEATBELT	2	10
				CH, REST	0	6
			CITY STR	NONE	15	39
				SEATBELT	1	6
				CH, REST	1	5
			INTERST	NONE	2	7
				SEATBELT	1	3
				CH, REST	0	2
		2 YEARS	STATEHWY	NONE	14	42
				SEATBELT	2	8
				CH, REST	1	6
			COUNTYRD	NONE	14	35
				SEATBELT	0	8
				CH, REST	0	5
			CITY STR	NONE	16	37
				SEATBELT	1	9
				CH, REST	0	0
			INTERST	NONE	1	4
				SEATBELT	1	0
				CH, REST	0	1
		3 YEARS	STATEHWY	NONE	9	53
				SEATBELT	2	6
				CH, REST	0	3
			COUNTYRD	NONE	9	26
				SEATBELT	2	5
				CH, REST	0	3
			CITY STR	NONE	11	30
				SEATBELT	1	8
				CH, REST	0	1
			INTERST	NONE	1	9
				SEATBELT	1	1
				CH, REST	0	1
		4 YEARS	STATEHWY	NONE	18	38
				SEATBELT	3	3
				CH, REST	0	0
			COUNTYRD	NONE	12	29
				SEATBELT	0	7
				CH, REST	0	0
			CITY STR	NONE	15	23
				SEATBELT	3	6
				CH, REST	0	2
			INTERST	NONE	3	7
				SEATBELT	1	3
				CH, REST	0	0

TABLE B-3 (continued)

30003599	1 YEAR	STATEHWY	NONE	9	37
			SEATBELT	0	10
			CH. REST	0	17
		COUNTYRD	NONE	9	27
			SEATBELT	0	8
			CH. REST	2	9
		CITY STR	NONE	10	36
			SEATBELT	0	5
			CH. REST	0	7
		INTERST	NONE	1	3
			SEATBELT	0	1
			CH. REST	1	2
	2 YEARS	STATEHWY	NONE	13	35
			SEATBELT	1	7
			CH. REST	1	5
		COUNTYRD	NONE	8	36
			SEATBELT	0	4
			CH. REST	2	5
		CITY STR	NONE	8	41
			SEATBELT	0	4
			CH. REST	0	1
		INTERST	NONE	1	7
			SEATBELT	0	1
			CH. REST	0	2
	3 YEARS	STATEHWY	NONE	15	46
			SEATBELT	0	8
			CH. REST	0	4
		COUNTYRD	NONE	11	53
			SEATBELT	1	5
			CH. REST	0	2
		CITY STR	NONE	12	43
			SEATBELT	2	5
			CH. REST	0	1
		INTERST	NONE	0	4
			SEATBELT	0	1
			CH. REST	0	0
	4 YEARS	STATEHWY	NONE	16	53
			SEATBELT	0	9
			CH. REST	1	1
		COUNTYRD	NONE	11	37
			SEATBELT	0	5
			CH. REST	0	0
		CITY STR	NONE	7	30
			SEATBELT	0	2
			CH. REST	0	0
		INTERST	NONE	2	3
			SEATBELT	1	2
			CH. REST	1	0

TABLE B-3 (continued)

3600 +	1 YEAR	STATEHWY	NONE	12	80
			SEATBELT	3	15
			CH. REST	1	33
		COUNTYRD	NONE	15	43
			SEATBELT	1	11
			CH. REST	1	20
		CITY STR	NONE	15	51
			SEATBELT	2	13
			CH. REST	2	13
		INTERST	NONE	1	8
			SEATBELT	3	1
			CH. REST	0	2
	2 YEARS	STATEHWY	NONE	20	78
			SEATBELT	2	18
			CH. REST	2	12
		COUNTYRD	NONE	19	73
			SEATBELT	2	12
			CH. REST	1	6
		CITY STR	NONE	23	67
			SEATBELT	2	10
			CH. REST	2	1
		INTERST	NONE	4	11
			SEATBELT	0	2
			CH. REST	0	1
	3 YEARS	STATEHWY	NONE	19	106
			SEATBELT	4	14
			CH. REST	0	4
		COUNTYRD	NONE	14	75
			SEATBELT	1	16
			CH. REST	1	4
		CITY STR	NONE	22	62
			SEATBELT	2	5
			CH. REST	2	3
		INTERST	NONE	2	12
			SEATBELT	0	3
			CH. REST	0	1
	4 YEARS	STATEHWY	NONE	28	74
			SEATBELT	6	16
			CH. REST	0	2
		COUNTYRD	NONE	26	103
			SEATBELT	2	18
			CH. REST	0	1
		CITY STR	NONE	20	70
			SEATBELT	2	8
			CH. REST	0	0
		INTERST	NONE	2	17
			SEATBELT	0	0
			CH. REST	0	1

TABLE B-3 (continued)

MODERATE LT 3000	1 YEAR	STATEHWY	NONE	19	72
			SEATBELT	3	18
			CH, REST	7	23
		COUNTYRD	NONE	12	47
			SEATBELT	3	11
			CH, REST	2	16
		CITY STR	NONE	24	46
			SEATBELT	5	12
			CH, REST	5	15
		INTERST	NONE	9	13
			SEATBELT	1	1
			CH, REST	1	4
	2 YEARS	STATEHWY	NONE	30	44
			SEATBELT	2	11
			CH, REST	5	7
		COUNTYRD	NONE	24	35
			SEATBELT	8	13
			CH, REST	2	4
		CITY STR	NONE	36	38
			SEATBELT	6	5
			CH, REST	0	3
		INTERST	NONE	4	16
			SEATBELT	0	7
			CH, REST	1	1
	3 YEARS	STATEHWY	NONE	35	78
			SEATBELT	6	12
			CH, REST	1	2
		COUNTYRD	NONE	15	56
			SEATBELT	5	16
			CH, REST	2	2
		CITY STR	NONE	40	49
			SEATBELT	5	6
			CH, REST	0	3
		INTERST	NONE	7	14
			SEATBELT	2	5
			CH, REST	0	0
	4 YEARS	STATEHWY	NONE	43	75
			SEATBELT	6	17
			CH, REST	0	1
		COUNTYRD	NONE	28	50
			SEATBELT	2	5
			CH, REST	1	3
		CITY STR	NONE	40	50
			SEATBELT	5	2
			CH, REST	0	0
		INTERST	NONE	8	10
			SEATBELT	2	1
			CH, REST	0	0

TABLE B-3 (continued)

30003599	1 YEAR	STATEHWY	NONE	19	62
			SEATBELT	3	9
			CH. REST	6	18
		COUNTYRD	NONE	15	49
			SEATBELT	1	11
			CH. REST	6	19
		CITY STR	NONE	17	47
			SEATBELT	0	9
			CH. REST	4	10
		INTERST	NONE	3	14
			SEATBELT	1	3
			CH. REST	0	3
	2 YEARS	STATEHWY	NONE	21	58
			SEATBELT	3	15
			CH. REST	1	9
		COUNTYRD	NONE	21	54
			SEATBELT	1	10
			CH. REST	4	3
		CITY STR	NONE	34	51
			SEATBELT	4	8
			CH. REST	0	8
		INTERST	NONE	4	17
			SEATBELT	1	2
			CH. REST	0	0
	3 YEARS	STATEHWY	NONE	40	76
			SEATBELT	5	12
			CH. REST	1	4
		COUNTYRD	NONE	18	60
			SEATBELT	3	8
			CH. REST	1	2
		CITY STR	NONE	39	50
			SEATBELT	4	6
			CH. REST	0	3
		INTERST	NONE	6	11
			SEATBELT	1	2
			CH. REST	0	1
	4 YEARS	STATEHWY	NONE	22	65
			SEATBELT	2	13
			CH. REST	0	3
		COUNTYRD	NONE	21	42
			SEATBELT	3	8
			CH. REST	0	0
		CITY STR	NONE	44	42
			SEATBELT	4	8
			CH. REST	0	1
		INTERST	NONE	5	20
			SEATBELT	1	1
			CH. REST	1	0

TABLE B-3 (continued)

3600 +	1 YEAR	STATEHWY	NONE	26	98
			SEATBELT	5	32
			CH, REST	6	34
		COUNTYRD	NONE	22	60
			SEATBELT	1	12
			CH, REST	2	26
		CITY STR	NONE	43	93
			SEATBELT	6	12
			CH, REST	3	10
		INTERST	NONE	8	15
			SEATBELT	1	3
			CH, REST	1	2
	2 YEARS	STATEHWY	NONE	30	104
			SEATBELT	0	24
			CH, REST	1	19
		COUNTYRD	NONE	30	77
			SEATBELT	3	20
			CH, REST	1	12
		CITY STR	NONE	63	79
			SEATBELT	2	11
			CH, REST	5	3
		INTERST	NONE	7	18
			SEATBELT	1	7
			CH, REST	0	3
	3 YEARS	STATEHWY	NONE	53	145
			SEATBELT	3	23
			CH, REST	0	7
		COUNTYRD	NONE	34	92
			SEATBELT	3	16
			CH, REST	1	3
		CITY STR	NONE	60	94
			SEATBELT	10	16
			CH, REST	1	3
		INTERST	NONE	5	26
			SEATBELT	4	4
			CH, REST	0	1
	4 YEARS	STATEHWY	NONE	50	147
			SEATBELT	4	27
			CH, REST	1	0
		COUNTYRD	NONE	40	85
			SEATBELT	6	22
			CH, REST	0	4
		CITY STR	NONE	75	96
			SEATBELT	10	10
			CH, REST	0	2
		INTERST	NONE	10	18
			SEATBELT	6	3
			CH, REST	0	0

TABLE B-3 (continued)

SEVERE	LT 3000	1 YEAR	STATEHWY	NONE	12	10
				SEATBELT	2	3
				CH. REST	6	6
			COUNTYRD	NONE	16	11
				SEATBELT	2	0
				CH. REST	5	5
			CITY STR	NONE	10	8
				SEATBELT	2	2
				CH. REST	4	1
			INTERST	NONE	5	2
				SEATBELT	1	1
				CH. REST	0	0
		2 YEARS	STATEHWY	NONE	17	20
				SEATBELT	2	3
				CH. REST	2	1
			COUNTYRD	NONE	14	13
				SEATBELT	3	2
				CH. REST	3	2
			CITY STR	NONE	4	9
				SEATBELT	1	0
				CH. REST	0	1
			INTERST	NONE	5	3
				SEATBELT	0	1
				CH. REST	0	2
		3 YEARS	STATEHWY	NONE	17	18
				SEATBELT	0	0
				CH. REST	0	2
			COUNTYRD	NONE	15	14
				SEATBELT	4	5
				CH. REST	0	1
			CITY STR	NONE	11	12
				SEATBELT	2	1
				CH. REST	1	1
			INTERST	NONE	3	5
				SEATBELT	0	1
				CH. REST	0	0
		4 YEARS	STATEHWY	NONE	13	12
				SEATBELT	2	2
				CH. REST	1	1
			COUNTYRD	NONE	18	13
				SEATBELT	3	3
				CH. REST	0	0
			CITY STR	NONE	11	3
				SEATBELT	2	0
				CH. REST	0	0
			INTERST	NONE	3	3
				SEATBELT	0	2
				CH. REST	0	0

TABLE B-3 (continued)

30003599	1 YEAR	STATEHWY	NONE	I	10	16
			SEATBELT	I	0	5
			CH, REST	I	3	2
		COUNTYRD	NONE	I	10	7
			SEATBELT	I	0	2
			CH, REST	I	1	4
		CITY STR	NONE	I	4	10
			SEATBELT	I	1	3
			CH, REST	I	2	1
		INTERST	NONE	I	2	3
			SEATBELT	I	0	0
			CH, REST	I	0	2
	2 YEARS	STATEHWY	NONE	I	16	16
			SEATBELT	I	2	2
			CH, REST	I	0	1
		COUNTYRD	NONE	I	9	12
			SEATBELT	I	0	2
			CH, REST	I	0	1
		CITY STR	NONE	I	9	5
			SEATBELT	I	1	2
			CH, REST	I	1	0
		INTERST	NONE	I	4	3
			SEATBELT	I	1	0
			CH, REST	I	0	0
	3 YEARS	STATEHWY	NONE	I	8	17
			SEATBELT	I	1	1
			CH, REST	I	0	2
		COUNTYRD	NONE	I	11	7
			SEATBELT	I	0	0
			CH, REST	I	0	2
		CITY STR	NONE	I	4	5
			SEATBELT	I	1	2
			CH, REST	I	0	0
		INTERST	NONE	I	2	2
			SEATBELT	I	0	0
			CH, REST	I	0	0
	4 YEARS	STATEHWY	NONE	I	13	17
			SEATBELT	I	0	2
			CH, REST	I	0	1
		COUNTYRD	NONE	I	9	7
			SEATBELT	I	0	0
			CH, REST	I	0	0
		CITY STR	NONE	I	10	4
			SEATBELT	I	0	1
			CH, REST	I	0	0
		INTERST	NONE	I	3	1
			SEATBELT	I	0	0
			CH, REST	I	0	0

TABLE B-3 (concluded)

3600 +	1 YEAR	STATEHWY	NONE	12	19
			SEATBELT	2	4
			CH. REST	4	1
		COUNTYRD	NONE	7	16
			SEATBELT	1	1
			CH. REST	2	1
		CITY STR	NONE	7	10
			SEATBELT	2	2
			CH. REST	4	4
		INTERST	NONE	2	2
			SEATBELT	1	0
			CH. REST	0	2
	2 YEARS	STATEHWY	NONE	8	14
			SEATBELT	1	6
			CH. REST	3	2
		COUNTYRD	NONE	8	11
			SEATBELT	1	3
			CH. REST	0	2
		CITY STR	NONE	8	9
			SEATBELT	1	0
			CH. REST	1	0
		INTERST	NONE	3	5
			SEATBELT	0	0
			CH. REST	0	0
	3 YEARS	STATEHWY	NONE	13	22
			SEATBELT	1	4
			CH. REST	2	0
		COUNTYRD	NONE	14	17
			SEATBELT	1	5
			CH. REST	1	0
		CITY STR	NONE	12	15
			SEATBELT	3	1
			CH. REST	0	0
		INTERST	NONE	5	0
			SEATBELT	2	1
			CH. REST	0	0
	4 YEARS	STATEHWY	NONE	17	35
			SEATBELT	4	2
			CH. REST	0	0
		COUNTYRD	NONE	12	14
			SEATBELT	2	3
			CH. REST	0	1
		CITY STR	NONE	13	11
			SEATBELT	1	2
			CH. REST	0	0
		INTERST	NONE	4	7
			SEATBELT	0	1
			CH. REST	0	0

THE TOTAL FREQUENCY IS 9145

TABLE B-4

FULLY CROSS-CLASSIFIED TABLE OF NEW YORK 1977
RAW DATA FOR KA/BCO INJURY DICHOTOMY

DRVAGE D	WEIGHT W	RDCLASS C	RESTRAINT R	KAXBCO (I) K+A	B+C+D
16-25	LT 3000	STATEHWY	NONE	8	240
			SEATBELT	1	30
			CH. REST	1	40
		COUNTYRD	NONE	7	145
			SEATBELT	1	25
			CH. REST	0	18
		CITY STR	NONE	8	131
			SEATBELT	0	9
			CH. REST	0	16
		INTERST	NONE	2	28
			SEATBELT	0	7
			CH. REST	0	1
	30003599	STATEHWY	NONE	4	267
			SEATBELT	0	28
			CH. REST	0	31
		COUNTYRD	NONE	6	154
			SEATBELT	0	20
			CH. REST	1	25
		CITY STR	NONE	5	103
			SEATBELT	0	10
			CH. REST	1	19
		INTERST	NONE	3	29
			SEATBELT	0	1
			CH. REST	0	2
	3600 +	STATEHWY	NONE	7	368
			SEATBELT	0	37
			CH. REST	0	29
		COUNTYRD	NONE	8	212
			SEATBELT	0	25
			CH. REST	0	19
		CITY STR	NONE	6	237
			SEATBELT	0	17
			CH. REST	0	15
		INTERST	NONE	1	34
			SEATBELT	0	6
			CH. REST	1	2

TABLE B-4 (continued)

26-30	LT 3000	STATEHWY	NONE	2	248
			SEATBELT	0	57
			CH. REST	1	39
		COUNTYRD	NONE	5	157
			SEATBELT	1	36
			CH. REST	0	49
		CITY STR	NONE	4	165
			SEATBELT	0	23
			CH. REST	0	24
		INTERST	NONE	2	50
			SEATBELT	0	7
			CH. REST	0	12
	30003599	STATEHWY	NONE	2	245
			SEATBELT	1	41
			CH. REST	0	34
		COUNTYRD	NONE	3	163
			SEATBELT	0	36
			CH. REST	2	26
		CITY STR	NONE	3	157
			SEATBELT	1	20
			CH. REST	0	21
		INTERST	NONE	3	49
			SEATBELT	0	9
			CH. REST	0	8
	3600 +	STATEHWY	NONE	10	430
			SEATBELT	0	58
			CH. REST	1	55
		COUNTYRD	NONE	6	300
			SEATBELT	0	68
			CH. REST	2	46
		CITY STR	NONE	1	238
			SEATBELT	0	41
			CH. REST	0	22
		INTERST	NONE	1	89
			SEATBELT	0	14
			CH. REST	0	8

TABLE B-4 (concluded)

31 +	LT 3000	STATEHWY	NONE	I	11	291
			SEATBELT	I	1	41
			CH, REST	I	0	35
		COUNTYRD	NONE	I	2	163
			SEATBELT	I	0	33
			CH, REST	I	1	20
		CITY STR	NONE	I	8	198
			SEATBELT	I	1	26
			CH, REST	I	0	14
		INTERST	NONE	I	2	60
			SEATBELT	I	1	14
			CH, REST	I	0	11
	3000-3599	STATEHWY	NONE	I	9	256
			SEATBELT	I	1	51
			CH, REST	I	0	21
		COUNTYRD	NONE	I	4	200
			SEATBELT	I	0	37
			CH, REST	I	0	27
		CITY STR	NONE	I	3	177
			SEATBELT	I	0	28
			CH, REST	I	0	19
		INTERST	NONE	I	4	49
			SEATBELT	I	0	17
			CH, REST	I	0	4
	3600 +	STATEHWY	NONE	I	11	723
			SEATBELT	I	2	123
			CH, REST	I	2	61
		COUNTYRD	NONE	I	15	482
			SEATBELT	I	0	87
			CH, REST	I	0	59
		CITY STR	NONE	I	9	477
			SEATBELT	I	0	60
			CH, REST	I	0	26
		INTERST	NONE	I	3	127
			SEATBELT	I	0	18
			CH, REST	I	0	13

THE TOTAL FREQUENCY IS 9685

TABLE B-5

FULLY CROSS-CLASSIFIED TABLE OF NEW YORK 1977
RAW DATA FOR KAB/CO INJURY DICHOTOMY

DRVAGE D	WEIGHT W	RDCLASS C	RESTRAINT R	KABXCO (I) K+A+B	C+O
16-25	LT 3000	STATEHWY	NONE	56	192
			SEATBELT	5	26
			CH. REST	4	37
		COUNTYRD	NONE	42	110
			SEATBELT	4	22
			CH. REST	4	14
		CITY STR	NONE	31	108
			SEATBELT	0	9
			CH. REST	3	13
		INTERST	NONE	9	21
			SEATBELT	0	7
			CH. REST	1	0
	30003599	STATEHWY	NONE	48	223
			SEATBELT	1	27
			CH. REST	4	27
		COUNTYRD	NONE	35	125
			SEATBELT	5	15
			CH. REST	9	17
		CITY STR	NONE	31	77
			SEATBELT	2	8
			CH. REST	4	16
		INTERST	NONE	8	24
			SEATBELT	0	1
			CH. REST	1	1
	3600 +	STATEHWY	NONE	72	303
			SEATBELT	3	34
			CH. REST	3	26
		COUNTYRD	NONE	42	178
			SEATBELT	1	24
			CH. REST	1	18
		CITY STR	NONE	42	201
			SEATBELT	2	15
			CH. REST	2	13
		INTERST	NONE	6	29
			SEATBELT	1	5
			CH. REST	1	2

TABLE B-5 (continued)

26-30	LT 3000	STATEHWY	NONE	38	212
			SEATBELT	5	52
			CH, REST	2	38
		COUNTYRD	NONE	38	124
			SEATBELT	5	32
			CH, REST	9	40
		CITY STR	NONE	30	139
			SEATBELT	2	21
			CH, REST	4	20
		INTERST	NONE	11	41
			SEATBELT	0	7
			CH, REST	4	8
	30003599	STATEHWY	NONE	45	202
			SEATBELT	3	39
			CH, REST	3	31
		COUNTYRD	NONE	37	129
			SEATBELT	4	32
			CH, REST	3	25
		CITY STR	NONE	36	124
			SEATBELT	6	15
			CH, REST	3	18
		INTERST	NONE	7	45
			SEATBELT	1	8
			CH, REST	C	8
	3600 +	STATEHWY	NONE	67	373
			SEATBELT	6	52
			CH, REST	9	47
		COUNTYRD	NONE	44	262
			SEATBELT	5	63
			CH, REST	10	38
		CITY STR	NONE	40	199
			SEATBELT	3	38
			CH, REST	2	20
		INTERST	NONE	14	76
			SEATBELT	3	11
			CH, REST	1	7

TABLE B-5 (concluded)

31 +	LT 3000	STATEHWY	NONE	I	54	248
			SEATBELT	I	3	39
			CH. REST	I	3	32
		COUNTYRD	NONE	I	42	123
			SEATBELT	I	3	30
			CH. REST	I	2	19
		CITY STR	NONE	I	41	165
			SEATBELT	I	10	17
			CH. REST	I	0	14
		INTERST	NONE	I	13	49
			SEATBELT	I	1	14
			CH. REST	I	0	11
	30003599	STATEHWY	NONE	I	48	217
			SEATBELT	I	3	49
			CH. REST	I	0	21
		COUNTYRD	NONE	I	36	168
			SEATBELT	I	6	31
			CH. REST	I	0	27
		CITY STR	NONE	I	36	144
			SEATBELT	I	5	23
			CH. REST	I	2	17
		INTERST	NONE	I	8	45
			SEATBELT	I	3	14
			CH. REST	I	0	4
	3600 +	STATEHWY	NONE	I	89	645
			SEATBELT	I	10	115
			CH. REST	I	10	53
		COUNTYRD	NONE	I	86	411
			SEATBELT	I	6	81
			CH. REST	I	5	54
		CITY STR	NONE	I	90	396
			SEATBELT	I	4	56
			CH. REST	I	3	23
		INTERST	NONE	I	21	109
			SEATBELT	I	3	15
			CH. REST	I	2	11

THE TOTAL FREQUENCY IS 9685

TABLE B-6

FULLY CROSS-CLASSIFIED TABLE OF NEW YORK 1977
RAW DATA FOR KABC/O INJURY DICHOTOMY

DRVAGE D	WEIGHT W	RDCLASS C	RESTRAINT R	KABCXO (I) K+A+B+C	O
16-25	LT 3000	STATEHWY	NONE	79	169
			SEATBELT	9	22
			CH, REST	5	36
		COUNTYRD	NONE	71	81
			SEATBELT	5	21
			CH, REST	5	13
		CITY STR	NONE	58	81
			SEATBELT	1	8
			CH, REST	4	12
		INTERST	NONE	13	17
			SEATBELT	1	6
			CH, REST	1	0
	30003599	STATEHWY	NONE	77	194
			SEATBELT	4	24
			CH, REST	7	24
		COUNTYRD	NONE	51	109
			SEATBELT	5	15
			CH, REST	10	16
		CITY STR	NONE	37	71
			SEATBELT	3	7
			CH, REST	5	15
		INTERST	NONE	11	21
			SEATBELT	0	1
			CH, REST	1	1
	3600 +	STATEHWY	NONE	99	276
			SEATBELT	5	32
			CH, REST	6	23
		COUNTYRD	NONE	72	148
			SEATBELT	5	20
			CH, REST	7	12
		CITY STR	NONE	72	171
			SEATBELT	8	9
			CH, REST	4	11
		INTERST	NONE	8	27
			SEATBELT	1	5
			CH, REST	1	2

TABLE B-6 (continued)

26-30	LT 3000	STATEHWY	NONE	72	178
			SEATBELT	7	50
			CH. REST	6	34
		COUNTYRD	NONE	63	99
			SEATBELT	7	30
			CH. REST	12	37
		CITY STR	NONE	55	114
			SEATBELT	8	15
			CH. REST	6	18
		INTERST	NONE	15	37
			SEATBELT	4	3
			CH. REST	4	8
	30003599	STATEHWY	NONE	67	180
			SEATBELT	5	37
			CH. REST	7	27
		COUNTYRD	NONE	55	111
			SEATBELT	6	30
			CH. REST	4	24
		CITY STR	NONE	62	98
			SEATBELT	6	15
			CH. REST	4	17
		INTERST	NONE	12	40
			SEATBELT	1	8
			CH. REST	1	7
	3600 +	STATEHWY	NONE	106	334
			SEATBELT	9	49
			CH. REST	13	43
		COUNTYRD	NONE	77	229
			SEATBELT	10	58
			CH. REST	15	33
		CITY STR	NONE	71	168
			SEATBELT	7	34
			CH. REST	3	19
		INTERST	NONE	26	64
			SEATBELT	4	10
			CH. REST	1	7

TABLE B-6 (concluded)

31 +	LT 3000	STATEHWY	NONE	I	86	216
			SEATBELT	I	5	37
			CH, REST	I	5	30
		COUNTYRD	NONE	I	65	100
			SEATBELT	I	7	26
			CH, REST	I	6	15
		CITY STR	NONE	I	72	134
			SEATBELT	I	12	15
			CH, REST	I	3	11
		INTERST	NONE	I	21	41
			SEATBELT	I	6	9
			CH, REST	I	1	10
	30003599	STATEHWY	NONE	I	73	192
			SEATBELT	I	6	46
			CH, REST	I	2	19
		COUNTYRD	NONE	I	61	143
			SEATBELT	I	8	29
			CH, REST	I	1	26
		CITY STR	NONE	I	63	117
			SEATBELT	I	7	21
			CH, REST	I	3	16
		INTERST	NONE	I	10	43
			SEATBELT	I	3	14
			CH, REST	I	1	3
	3600 +	STATEHWY	NONE	I	156	578
			SEATBELT	I	15	110
			CH, REST	I	11	52
		COUNTYRD	NONE	I	126	371
			SEATBELT	I	8	79
			CH, REST	I	12	47
		CITY STR	NONE	I	163	323
			SEATBELT	I	14	46
			CH, REST	I	4	22
		INTERST	NONE	I	40	90
			SEATBELT	I	4	14
			CH, REST	I	3	10

THE TOTAL FREQUENCY IS 9685

TABLE B-7

FULLY CROSS-CLASSIFIED TABLE OF NEW JERSEY 1975 RAW DATA FOR KAB/CO INJURY DICHOTOMY

DRVAGE D	NUMVEH P	RDCLASS C	SEATPOS S	RESTRAINT R	KABXCO (I) K+A+B	C+O
15-25	LT 25K	STATEHWY	FRONT	NONE	29	161
				SEATBELT	0	26
				CH. REST	2	14
			BACK	NONE	18	146
				SEATBELT	4	20
				CH. REST	4	22
		COUNTYRD	FRONT	NONE	32	163
				SEATBELT	0	19
				CH. REST	2	22
			BACK	NONE	18	107
				SEATBELT	0	9
				CH. REST	3	14
		CITY STR	FRONT	NONE	26	89
				SEATBELT	2	8
				CH. REST	0	7
			BACK	NONE	0	40
				SEATBELT	0	11
				CH. REST	1	10
	25K +	STATEHWY	FRONT	NONE	18	87
				SEATBELT	4	26
				CH. REST	1	7
			BACK	NONE	5	80
				SEATBELT	1	13
				CH. REST	0	12
		COUNTYRD	FRONT	NONE	27	115
				SEATBELT	2	29
				CH. REST	2	14
			BACK	NONE	16	99
				SEATBELT	0	10
				CH. REST	1	6
		CITY STR	FRONT	NONE	20	155
				SEATBELT	2	28
				CH. REST	1	13
			BACK	NONE	9	89
				SEATBELT	1	7
				CH. REST	1	7

TABLE B-7 (continued)

26-30	LT 25K	STATEHWY	FRONT	NONE	26	157
				SEATBELT	2	37
				CH. REST	3	35
			BACK	NONE	11	149
				SEATBELT	0	33
				CH. REST	3	25
		COUNTYRD	FRONT	NONE	24	152
				SEATBELT	1	51
				CH. REST	1	19
			BACK	NONE	23	143
				SEATBELT	1	40
				CH. REST	3	10
		CITY STR	FRONT	NONE	16	65
				SEATBELT	0	16
				CH. REST	0	24
			BACK	NONE	5	51
				SEATBELT	0	11
				CH. REST	0	19
	25K +	STATEHWY	FRONT	NONE	11	89
				SEATBELT	4	27
				CH. REST	5	15
			BACK	NONE	18	82
				SEATBELT	0	20
				CH. REST	1	17
		COUNTYRD	FRONT	NONE	12	126
				SEATBELT	1	27
				CH. REST	2	15
			BACK	NONE	14	103
				SEATBELT	0	25
				CH. REST	4	22
		CITY STR	FRONT	NONE	25	96
				SEATBELT	2	16
				CH. REST	0	7
			BACK	NONE	10	106
				SEATBELT	1	13
				CH. REST	2	5

TABLE B-7 (concluded)

31 +	LT 25K	STATEHWY	FRONT	NONE	24	167
				SEATBELT	4	38
				CH, REST	2	15
			BACK	NONE	21	221
				SEATBELT	4	41
				CH, REST	5	29
		COUNTYRD	FRONT	NONE	29	206
				SEATBELT	1	50
				CH, REST	2	23
			BACK	NONE	29	198
				SEATBELT	0	35
				CH, REST	4	22
		CITY STR	FRONT	NONE	17	88
				SEATBELT	2	26
				CH, REST	1	24
			BACK	NONE	7	104
				SEATBELT	0	15
				CH, REST	0	13
	25K +	STATEHWY	FRONT	NONE	17	111
				SEATBELT	0	25
				CH, REST	0	9
			BACK	NONE	7	162
				SEATBELT	0	28
				CH, REST	2	13
		COUNTYRD	FRONT	NONE	30	140
				SEATBELT	4	35
				CH, REST	2	20
			BACK	NONE	8	161
				SEATBELT	0	34
				CH, REST	2	16
		CITY STR	FRONT	NONE	28	152
				SEATBELT	3	18
				CH, REST	2	15
			BACK	NONE	16	148
				SEATBELT	0	18
				CH, REST	1	8

THE TOTAL FREQUENCY IS 6718

TABLE B-8

FULLY CROSS-CLASSIFIED TABLE OF NEW JERSEY 1975 RAW DATA FOR KABC/O INJURY DICHOTOMY

DRVAGE D	RURURB P	RDCLASS C	SEATPOS S	RESTRAINT R	KABCXO (I) K+A+B+C	O
15-25	LT 25K	STATEHWY	FRONT	NONE	72	118
				SEATBELT	4	22
				CH. REST	6	10
			BACK	NONE	41	123
				SEATBELT	5	19
				CH. REST	7	19
		COUNTYRD	FRONT	NONE	74	121
				SEATBELT	1	18
				CH. REST	7	17
			BACK	NONE	41	84
				SEATBELT	1	8
				CH. REST	7	10
		CITY STR	FRONT	NONE	49	66
				SEATBELT	3	7
				CH. REST	2	5
			BACK	NONE	5	35
				SEATBELT	2	9
				CH. REST	2	9
	25K +	STATEHWY	FRONT	NONE	48	57
				SEATBELT	11	19
				CH. REST	2	6
			BACK	NONE	26	59
				SEATBELT	2	12
				CH. REST	2	10
		COUNTYRD	FRONT	NONE	68	74
				SEATBELT	7	24
				CH. REST	4	12
			BACK	NONE	42	73
				SEATBELT	3	7
				CH. REST	2	5
		CITY STR	FRONT	NONE	84	91
				SEATBELT	7	23
				CH. REST	4	10
			BACK	NONE	28	70
				SEATBELT	2	6
				CH. REST	1	7

TABLE B-8 (continued)

26-30	LT 25K	STATEHWY	FRONT	NONE	60	123
				SEATBELT	3	36
				CH. REST	11	27
			BACK	NONE	37	123
				SEATBELT	7	26
				CH. REST	11	17
		COUNTYRD	FRONT	NONE	60	116
				SEATBELT	6	46
				CH. REST	7	13
			BACK	NONE	48	118
				SEATBELT	5	36
				CH. REST	5	8
		CITY STR	FRONT	NONE	29	52
				SEATBELT	0	16
				CH. REST	2	22
			BACK	NONE	14	42
				SEATBELT	0	11
				CH. REST	3	16
	25K +	STATEHWY	FRONT	NONE	46	54
				SEATBELT	13	18
				CH. REST	9	11
			BACK	NONE	29	71
				SEATBELT	2	18
				CH. REST	1	17
		COUNTYRD	FRONT	NONE	61	77
				SEATBELT	5	23
				CH. REST	3	14
			BACK	NONE	39	78
				SEATBELT	1	24
				CH. REST	9	17
		CITY STR	FRONT	NONE	70	51
				SEATBELT	5	13
				CH. REST	2	5
			BACK	NONE	31	85
				SEATBELT	2	12
				CH. REST	3	4

TABLE B-8 (concluded)

31 +	LT 25K	STATEHWY	FRONT	NONE	67	124
				SEATBELT	9	33
				CH, REST	3	14
			BACK	NONE	52	190
				SEATBELT	10	35
				CH, REST	11	23
		COUNTYRD	FRONT	NONE	70	165
				SEATBELT	3	48
				CH, REST	4	21
			BACK	NONE	60	167
				SEATBELT	0	35
				CH, REST	6	20
		CITY STR	FRONT	NONE	38	67
				SEATBELT	4	24
				CH, REST	4	21
			BACK	NONE	22	89
				SEATBELT	3	12
				CH, REST	3	10
	25K +	STATEHWY	FRONT	NONE	48	80
				SEATBELT	6	19
				CH, REST	1	8
			BACK	NONE	41	128
				SEATBELT	4	24
				CH, REST	2	13
		COUNTYRD	FRONT	NONE	69	101
				SEATBELT	12	27
				CH, REST	10	12
			BACK	NONE	36	133
				SEATBELT	6	28
				CH, REST	5	13
		CITY STR	FRONT	NONE	88	92
				SEATBELT	9	12
				CH, REST	6	11
			BACK	NONE	43	121
				SEATBELT	2	16
				CH, REST	4	5

THE TOTAL FREQUENCY IS 6718

TABLE B-9

FULLY CROSS-CLASSIFIED TABLE OF IDAHO 1976-1978 RAW DATA FOR KABC/O INJURY DICHOTOMY

DAMAGE X	OCCAGE U	DRVAGE D	RESTRAINT R	KABCXO (I) K+A+B+C	O
LT 3500	1 YEAR	16-25	NONE	39	220
			SEATBELT	1	33
			CH. REST	5	20
		26-30	NONE	11	133
			SEATBELT	2	36
			CH. REST	1	23
		31 +	NONE	8	125
			SEATBELT	1	9
			CH. REST	0	6
	2 YEARS	16-25	NONE	26	222
			SEATBELT	1	19
			CH. REST	0	6
		26-30	NONE	15	161
			SEATBELT	2	22
			CH. REST	0	8
		31 +	NONE	13	119
			SEATBELT	0	21
			CH. REST	0	2
	3 YEARS	16-25	NONE	28	150
			SEATBELT	0	5
			CH. REST	0	6
		26-30	NONE	19	138
			SEATBELT	0	14
			CH. REST	0	1
		31 +	NONE	16	140
			SEATBELT	0	21
			CH. REST	0	0
	4 YEARS	16-25	NONE	25	94
			SEATBELT	0	10
			CH. REST	0	2
		26-30	NONE	18	148
			SEATBELT	0	15
			CH. REST	0	1
		31 +	NONE	16	176
			SEATBELT	2	11
			CH. REST	0	1

TABLE B-9 (concluded)

3501 +	1 YEAR	16-25	NONE	51	102
			SEATBELT	6	9
			CH. REST	5	9
		26-30	NONE	23	58
			SEATBELT	3	6
			CH. REST	2	9
		31 +	NONE	14	39
			SEATBELT	2	10
			CH. REST	2	6
	2 YEARS	16-25	NONE	36	86
			SEATBELT	2	8
			CH. REST	1	1
		26-30	NONE	21	58
			SEATBELT	2	6
			CH. REST	2	4
		31 +	NONE	17	42
			SEATBELT	1	6
			CH. REST	4	1
	3 YEARS	16-25	NONE	29	43
			SEATBELT	1	6
			CH. REST	0	1
		26-30	NONE	27	53
			SEATBELT	2	3
			CH. REST	0	2
		31 +	NONE	24	59
			SEATBELT	2	6
			CH. REST	1	1
	4 YEARS	16-25	NONE	21	42
			SEATBELT	0	3
			CH. REST	0	0
		26-30	NONE	31	44
			SEATBELT	2	3
			CH. REST	0	0
		31 +	NONE	22	51
			SEATBELT	2	6
			CH. REST	0	1

THE TOTAL FREQUENCY IS 3509

APPENDIX C

SUMMARY OF THE MARGINAL ASSOCIATION OF MODEL EFFECTS

TABLE C-1

SUMMARY OF TESTS OF MARGINAL ASSOCIATIONS OF MODEL EFFECTS FOR THREE INJURY DICHOTOMIES

NEW YORK 1974 SAMPLE

Effect	KA vs. BCO			KAB vs. CO			KABC vs. 0		
	LR X^2	df	Prob.	LR X^2	df	Prob.	LR X^2	df	Prob.
Injury x Restraint	9.58	2	0.0083	35.32	2	0.0000	59.65	2	0.0000
Injury x Rd. Class	5.16	3	0.1602	22.22*	3	0.0001	79.91	3	0.0000
Injury x Child Age	--	-	--	12.69*	3	0.0054	38.12*	3	0.0000
Injury x Weight	--	-	--	37.95*	2	0.0000	39.16*	2	0.0000
Injury x Damage	65.49*	2	0.0000	259.52	2	0.0000	278.30	2	0.0000
Restraint x Rd. Class	49.75	6	0.0000	49.75*	6	0.0000	47.70*	6	0.0000
Restraint x Child Age	570.39*	6	0.0000	570.39*	6	0.0000	574.69*	6	0.0000
Restraint x Weight	13.55*	4	0.0089	13.55*	4	0.0089	14.49*	4	0.0059
Restraint x Damage	--	-	--	3.27	4	0.5131	3.27	4	0.5141
Rd. Class x Child Age	--	-	--	--	-	--	9.76*	9	0.3701
Rd. Class x Weight	7.26	6	0.2979	7.26	6	0.2979	7.16	6	0.3060
Rd. Class x Damage	54.48	6	0.0000	54.48	6	0.0000	54.98	6	0.0000
Child Age x Weight	21.64*	6	0.0014	21.64*	6	0.0014	22.54*	6	0.0010
Weight x Damage	57.96	4	0.0000	57.96	4	0.0000	62.70	4	0.0000
Injury x Restraint x Rd. Class	17.25*	6	0.0084	--	-	--	--	-	--
Injury x Restraint x Damage	--	-	--	13.85*	4	0.0078	10.51*	4	0.0327
Injury x Rd. Class x Damage	--	-	--	--	-	--	15.49*	6	0.0168
Rd. Class x Weight x Damage	21.21*	12	0.0474	21.21*	12	0.0474	22.65*	12	-.0309
SUMMARY OF MODEL	641.42	787	1.0000	780.99	780	0.4833	734.55	765	0.7799

*Effect is directly specified in model. All others are forced into the model by hierarchical inclusion.

TABLE C-2

SUMMARY OF TESTS OF MARGINAL ASSOCIATIONS OF MODEL EFFECTS FOR THREE INJURY DICHOTOMIES

NEW YORK 1977 SAMPLE

Effect	KA vs. BCO			KAB vs. CO			KABC vs. 0		
	LR x^2	df	Prob.	LR x^2	df	Prob.	LR x^2	df	Prob.
Injury x Restraint	15.76*	2	0.0004	57.89	2	0.0000	91.20	2	0.0000
Injury x Rd. Class	--	-	--	16.64	3	0.0008	55.05	3	0.0000
Injury x Weight	6.83*	2	0.0329	21.62	2	0.0000	33.78*	2	0.0000
Injury x Dr. Age	9.85*	2	0.0073	19.04*	2	0.0001	16.32*	2	0.0003
Restraint x Rd. Class	39.43*	6	0.0000	39.43	6	0.0000	39.43	6	0.0000
Restraint x Weight	28.15*	4	0.0000	28.15	4	0.0000	28.15*	4	0.0000
Restraint x Dr. Age	65.56*	4	0.0000	65.56*	4	0.0000	65.56*	4	0.0000
Rd. Class x Weight	7.83	6	0.2508	7.83	6	0.2508	7.83	6	0.2508
Rd. Class x Dr. Age	45.17	6	0.0000	45.17	6	0.0000	45.17	6	0.0000
Veh. Wt. x Dr. Age	143.29	4	0.0000	143.29	4	0.0000	143.29	4	0.0000
Injury x Restraint x Rd. Class	--	-	--	4.21	6	0.6477	14.44*	6	0.0251
Injury x Restraint x Weight	--	-	--	4.45	4	0.3484	--	-	--
Injury x Rd. Class x Weight	--	-	--	8.14	6	0.2278	--	-	--
Restraint x Rd. Class x Weight	--	-	--	10.61	12	0.5623	--	-	--
Rd. Class x Weight x Dr. Age	23.51*	12	0.0237	23.51*	12	0.0237	23.51*	12	0.0237
Injury x Restraint x Rd. Class x Weight	--	-	--	20.32*	12	0.0613	--	-	--
SUMMARY OF MODEL	151.73	157	0.6039	129.51	114	0.1519	149.46	148	0.4509

*Effect is specified directly in the model. All others are forced into the model by hierarchical inclusion.

TABLE C-3

SUMMARY OF MARGINAL ASSOCIATIONS OF MODEL EFFECTS FOR NEW JERSEY 1975 SAMPLE

Effect	INJURY DICHOTOMY					
	KAB vs. CO			KABC vs. O		
	LR X^2	df	Prob.	LR X^2	df	Prob.
Injury x Restraint	54.68	2	0.0000	106.89	2	0.0000
Injury x Seat Position	28.21	1	0.0000	100.18	1	0.0000
Injury x Rd. Class	1.70	2	0.4283	7.99	2	0.0185
Injury x City Size	0.00	1	0.9734	40.67	1	0.0000
Injury x Dr. Age	9.22	2	0.0099	22.43*	2	0.0000
Restraint x Seat Position	7.83	2	0.0199	7.83	2	0.0199
Restraint x Rd. Class	12.18	4	0.0160	12.18	4	0.0160
Restraint x City Size	10.97	2	0.0042	10.97	2	0.0042
Restraint x Dr. Age	32.98	4	0.0000	32.98	4	0.0000
Seat Position x Rd. Class	27.50	2	0.0000	27.50	2	0.0000
Seat Position x City Size	0.01	1	0.9032	0.01	1	0.9032
Seat Position x Dr. Age	48.33	2	0.0000	48.33	2	0.0000
Rd. Class x City Size	195.25	2	0.0000	195.25	2	0.0000
Rd. Class x Dr. Age	9.33	4	0.0535	9.33	4	0.0535
City Size x Dr. Age	2.50	2	0.2872	2.50	2	0.2872
Injury x Restraint x Seat Pos.	11.14*	2	0.0038	13.63	2	0.0011
Injury x Restraint x Rd. Class	15.90*	4	0.0032	16.23*	4	0.0027
Injury x Restraint x City Size	--	-	--	6.68	2	0.0354
Injury x Seat Pos. x Rd. Class	8.65	2	0.0133	12.72*	2	0.0017
Injury x Seat Pos. x City Size	2.13	1	0.1443	14.54	1	0.0001
Injury x Seat Pos. x Dr. Age	2.66	2	0.2646	--	-	--
Injury x Rd. Class x City Size	0.83	2	0.6619	--	-	--
Injury x Rd. Class x Dr. Age	3.47	4	0.4825	--	-	--
Injury x City Size x Dr. Age	2.85	2	0.2407	--	-	--
Restraint x Seat Pos. x City Size	1.63	2	0.4418	1.63	2	0.4418
Restraint x Seat Pos. x Dr. Age	4.86	4	0.3022	4.86	4	0.3022
Restraint x Rd. Class x City Size	30.44	4	0.0000	30.44	4	0.0000

TABLE C-3 (continued)

Effect	INJURY DICHOTOMY					
	KAB vs. CO			KABC vs. 0		
	LR x^2	df	Prob.	LR x^2	df	Prob.
Restraint x Rd. Class x Dr. Age	14.53	8	0.0639	14.53	8	0.0689
Restraint x City Size x Dr. Age	10.13	4	0.0383	10.13	4	0.0383
Seat Pos. x Rd. Class x City Size	0.50	2	0.7781	--	-	--
Seat Pos. x Rd. Class x Dr. Age	12.97	4	0.0114	12.97*	4	0.0114
Seat Pos. x City Size x Dr. Age	2.20	2	0.3326	2.20	2	0.3326
Rd. Class x City Size x Dr. Age	5.93	4	0.2044	5.93	4	0.2044
Injury x Restraint x Seat Pos. x City Size	--	-	--	6.17*	2	0.0457
Injury x Seat Pos. x Rd. Class x City Size	11.28	2	0.0035	--	-	--
Injury x Seat Pos. x Rd. Class x Dr. Age	2.41	4	0.6616	--	-	--
Injury x Seat Pos. x City Size x Dr. Age	6.22	2	0.0445	--	-	--
Injury x Rd. Class x City Size x Dr. Age	10.68	4	0.0304	--	-	--
Restraint x Seat Pos. x City Size x Dr. Age	13.04*	4	0.0111	13.04*	4	0.0111
Restraint x Rd. Class x City Size x Dr. Age	21.27*	8	0.0065	21.27*	8	0.0065
Seat Pos. x Rd. Class x City Size x Dr. Age	2.09	4	0.7189	--	-	--
Injury x Seat Pos. x Rd. Class x City Size x Dr. Age	12.01*	4	0.0172	--	-	--
SUMMARY OF MODEL	99.95	88 of 215	0.1808	121.36	116 of 215	0.3482

*Effect is specified directly in the model. All others are forced into the model by hierarchical inclusion.

TABLE C-4

SUMMARY OF MARGINAL ASSOCIATIONS OF MODEL EFFECTS FOR KABC/O INJURY DICHOTOMY

IDAHO 1976-1978 SAMPLE

Effect	KABC vs. O		
	LR X^2	df	Prob.
Injury x Restraint	12.63*	2	0.0018
Injury x Dr. Age	13.80*	2	0.0010
Injury x Damage	219.76*	1	0.0000
Restraint x Dr. Age	15.27	4	0.0042
Restraint x Child Age	111.15*	6	0.0000
Restraint x Damage Age	3.20	2	0.2019
Dr. Age x Child Age	128.37*	6	0.0000
Dr. Age x Damage	1.22	2	0.5446
Restraint x Dr. Age x Damage	14.82*	4	0.0051
SUMMARY OF MODEL	110.13	1.05	0.3468

*Effect is specified directly in the model. All others are forced into the model by hierarchical inclusion.

APPENDIX D

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

TABLE D-1

SUMMARY OF CHILD RESTRAINT EFFECTIVENESS STUDY USING NEW YORK 1974 DATA (OBSERVED, NOT ADJUSTED)

Total Cases = 9103

INJURY CATEGORIES	INJURY DISTRIBUTIONS: UNRESTRAINED CHILDREN N	UNRESTRAINED CHILDREN %	RESTRAINED CHILDREN: CHILD RESTRAINT N	CHILD RESTRAINT %	SEATBELT N	SEATBELT %	EITHER DEVICE N	EITHER DEVICE %	ALL CHILDREN N	ALL CHILDREN %
K+A	227	2.5	17	0.2	20	0.2	37	0.4	264	2.9
B+C+0	6979	76.7	680	7.5	1180	13.0	1860	20.4	8839	97.1
K+A+B	1387	15.2	103	1.1	155	1.7	258	2.8	1645	18.1
C+0	5819	63.9	594	6.5	1045	11.5	1639	18.0	7458	81.9
K+A+B+C *	2231	24.4	142	1.6	280	3.1	422	4.6	2653	29.0
0	5008	54.8	559	6.1	925	10.1	1484	16.2	6492	71.0
K+A+B+C+0	7206	79.2	697	7.7	1200	13.2	1897	20.8	9103	100.0

INJURY CATEGORIES	INJURY RATES (PERCENT): UNRESTRAINED CHILDREN	RESTRAINED CHILDREN: CHILD RESTRAINT	SEATBELT	EITHER DEVICE	ALL CHILDREN
K+A	3.15	2.44	1.67	1.95	2.90
K+A+B	19.25	14.78	12.92	13.60	18.07
K+A+B+C	30.62	20.26	23.24	22.14	29.01

INJURY CATEGORIES	RESTRAINT USAGE	SUMMARY OF EFFECTIVENESS VALUES (PERCENT): EFFECTIVENESS	STANDARD DEVIATION	95% CONFIDENCE INTERVAL FROM	TO
K+A	CHILD RESTRAINT	22.23	19.41	-5.61	54.07
	SEATBELT	46.86	12.36	26.60	67.12
	EITHER DEVICE	37.81	11.00	19.77	55.85
K+A+B	CHILD RESTRAINT	23.18	7.23	11.32	35.04
	SEATBELT	32.85	5.29	24.17	41.53
	EITHER DEVICE	29.30	4.44	22.02	36.58
K+A+B+C	CHILD RESTRAINT	34.25	5.06	25.95	42.55
	SEATBELT	24.58	4.17	17.75	31.42
	EITHER DEVICE	28.14	3.34	22.66	33.61

* Row totals for the K+A+B+C vs 0 injury categories do not equal the row totals for K+A+B+C+0, due to the inclusion of 43 cases classified as "injured - extent unknown."

TABLE D-2

SUMMARY OF CHILD RESTRAINT EFFECTIVENESS STUDY USING NEW YORK 1977 DATA (OBSERVED, NOT ADJUSTED)

Total Cases = 9685

INJURY CATEGORIES	INJURY DISTRIBUTIONS									
	UNRESTRAINED CHILDREN		RESTRAINED CHILDREN						ALL CHILDREN	
			CHILD RESTRAINT		SEATBELT		EITHER DEVICE			
	N	%	N	%	N	%	N	%	N	%
K+A	188	1.9	13	0.1	11	0.1	24	0.2	212	2.2
B+C+O	7442	76.8	871	9.0	1160	12.0	2031	21.0	9473	97.8
K+A+B	1393	14.4	114	1.2	124	1.3	238	2.5	1631	16.8
C+O	6237	64.4	770	8.0	1047	10.8	1817	18.8	8054	83.2
K+A+B+C	2265	23.4	184	1.9	216	2.2	400	4.1	2665	27.5
O	5365	55.4	700	7.2	955	9.9	1655	17.1	7020	72.5
K+A+B+C+O	7630	78.8	884	9.1	1171	12.1	2055	21.2	9685	100.0

INJURY CATEGORIES	INJURY RATES (PERCENT)				
	UNRESTRAINED CHILDREN	RESTRAINED CHILDREN			ALL CHILDREN
		CHILD RESTRAINT	SEATBELT	EITHER DEVICE	
K+A	2.46	1.47	0.94	1.17	2.19
K+A+B	18.26	12.90	10.59	11.58	16.84
K+A+B+C	29.69	20.81	18.45	19.46	27.52

INJURY CATEGORIES	RESTRAINT USAGE	SUMMARY OF EFFECTIVENESS VALUES (PERCENT)			
		EFFECTIVENESS	STANDARD DEVIATION	95% CONFIDENCE INTERVAL	
				FROM	TO
K+A	CHILD RESTRAINT	39.99	17.18	11.81	68.17
	SEATBELT	61.67	11.90	42.16	81.18
	EITHER DEVICE	52.35	10.35	35.37	69.32
K+A+B	CHILD RESTRAINT	29.32	6.42	18.80	39.84
	SEATBELT	41.96	5.13	33.55	50.38
	EITHER DEVICE	36.53	4.17	29.69	43.36
K+A+B+C	CHILD RESTRAINT	29.86	4.77	22.04	37.68
	SEATBELT	37.84	3.97	31.32	44.36
	EITHER DEVICE	34.41	3.16	29.22	39.60

TABLE D-3

SUMMARY OF CHILD RESTRAINT EFFECTIVENESS STUDY USING NEW JERSEY 1975 DATA (OBSERVED, NOT ADJUSTED)

Total Cases = 6718

INJURY DISTRIBUTIONS

INJURY CATEGORIES	UNRESTRAINED CHILDREN N	UNRESTRAINED CHILDREN %	RESTRAINED CHILDREN: CHILD RESTRAINT N	CHILD RESTRAINT %	SEATBELT N	SEATBELT %	EITHER DEVICE N	EITHER DEVICE %	ALL CHILDREN N	ALL CHILDREN %
K+A+B	646	9.6	65	1.0	46	0.7	111	1.7	757	11.3
C+O	4508	67.1	568	8.5	885	13.2	1453	21.6	5961	88.7
K+A+B+C	1736	25.8	171	2.5	165	2.5	336	5.0	2072	30.8
O	3418	50.9	462	6.9	766	11.4	1228	18.3	4646	69.2
K+A+B+C+O	5154	76.7	633	9.4	931	13.9	1564	23.3	6718	100.0

INJURY RATES (PERCENT)

INJURY CATEGORIES	UNRESTRAINED CHILDREN	RESTRAINED CHILDREN: CHILD RESTRAINT	SEATBELT	EITHER DEVICE	ALL CHILDREN
K+A+B	12.53	10.27	4.94	7.10	11.27
K+A+B+C	33.68	27.01	17.72	21.48	30.84

INJURY CATEGORIES	RESTRAINT USAGE	SUMMARY OF EFFECTIVENESS VALUES (PERCENT): EFFECTIVENESS	STANDARD DEVIATION	95% CONFIDENCE INTERVAL FROM	TO
K+A+B	CHILD RESTRAINT	17.96	10.12	1.36	34.56
	SEATBELT	60.53	5.87	50.90	70.15
	EITHER DEVICE	43.30	5.61	34.10	52.49
K+A+B+C	CHILD RESTRAINT	19.77	5.47	10.79	28.75
	SEATBELT	47.36	3.86	41.03	53.69
	EITHER DEVICE	36.19	3.33	30.73	41.65

TABLE D-4

SUMMARY OF CHILD RESTRAINT EFFECTIVENESS STUDY USING IDAHO 1976-78 DATA (OBSERVED, NOT ADJUSTED)

Total Cases = 3509

INJURY CATEGORIES	INJURY DISTRIBUTIONS									
	UNRESTRAINED CHILDREN		RESTRAINED CHILDREN						ALL CHILDREN	
			CHILD RESTRAINT		SEATBELT		EITHER DEVICE			
	N	%	N	%	N	%	N	%	N	%
K+A+B+C	550	15.7	23	0.7	34	1.0	57	1.6	607	17.3
O	2503	71.3	111	3.2	288	8.2	399	11.4	2902	82.7
K+A+B+C+O	3053	87.0	134	3.8	322	9.2	456	13.0	3509	100.0

INJURY CATEGORIES	INJURY RATES (PERCENT)				
	UNRESTRAINED CHILDREN	RESTRAINED CHILDREN			ALL CHILDREN
		CHILD RESTRAINT	SEATBELT	EITHER DEVICE	
K+A+B+C	18.02	17.16	10.56	12.50	17.30

INJURY CATEGORIES	RESTRAINT USAGE	SUMMARY OF EFFECTIVENESS VALUES (PERCENT)			
		EFFECTIVENESS	STANDARD DEVIATION	95% CONFIDENCE INTERVAL	
				FROM	TO
K+A+B+C	CHILD RESTRAINT	4.58	18.51	-25.77	34.93
	SEATBELT	41.30	9.80	25.22	57.38
	EITHER DEVICE	30.51	9.04	15.69	45.33

APPENDIX E

CONFIDENCE LIMITS FOR EFFECTIVENESS ESTIMATES BASED UPON THE SIMPLE RATIO OF PROBABILITIES

APPENDIX E

CONFIDENCE LIMITS FOR A SIMPLE RATIO OF PROBABILITIES

1. Objective

To estimate a confidence interval for

$$R = \frac{p_1}{p_2} \qquad (1)$$

where $p_i = x_i/n_i$, and the x_i are bionomially distributed random variables.

2. Approach

We write

$$R = \frac{\pi_1}{\pi_2} \times \frac{(1+\varepsilon_1)}{(1+\varepsilon_2)} \qquad (2)$$

where the π_i are the expected values of the p_i.

Then we study

$$r = \frac{(1+\varepsilon_1)}{(1+\varepsilon_2)} \qquad (3)$$

by expanding the fraction in a power series in ε_2. These series expressions hold only if $|\varepsilon| < 1$; that requires p to be restricted to the range $0 \ldots 2\pi$, or x to the range $0 \ldots 2n\pi$. Since $\sigma(x) = \sqrt{n\pi(1-\pi)}$, this is a $\pm$ 2σ range for $n\pi = 4(1-\pi)$. Since $n\pi = m$ is usually much larger than 4, the restriction is violated only by a minimal fraction of all cases. We calculate the first four moments of r to various degrees of approximation and compare them. Finally, we will explore by numerical examples how large the data base from which r is estimated has to be in order to use the simple approximation.

3. Some Basic Formulas

The ε are implicitly defined as:

$$\varepsilon = \frac{p-\pi}{\pi} . \tag{4}$$

Since $p = x/n$

$$\varepsilon = \frac{x-n\pi}{n\,\pi} . \tag{5}$$

Therefore, for the central moments the relation

$$\mu_i(\varepsilon) = \frac{\mu_i(x)}{(n\pi)^i} \tag{6}$$

holds. Since x was assumed to be binomially distributed,

$$\left.\begin{aligned} \mu_1(x) &= 0 \\ \mu_2(x) &= n\pi(1-\pi) \\ \mu_3(x) &= n\pi(1-\pi)(1-2\pi) \\ \mu_4(x) &= 3n^2\pi^2(1-\pi)^2 + n\pi(1-\pi)(1-6\pi(1-\pi)), \end{aligned}\right\} \tag{7}$$

therefore

$$\left.\begin{aligned} \mu_1(\varepsilon) &= 0 \\ \mu_2(\varepsilon) &= \frac{1-\pi}{n\,\pi} \\ \mu_3(\varepsilon) &= \frac{(1-\pi)(1-2\pi)}{(n\pi)^2} \\ \mu_4(\varepsilon) &= \frac{3(1-\pi)^2}{(n\pi)^2} + \frac{(1-\pi)(1-6\pi(1-\pi))}{(n\pi)^3} \end{aligned}\right\} \tag{8}$$

Introducing the number of "successes" (or injuries in our context) $m = n\pi$, and assuming π to be negligibly small relative to 1, one obtains the approximation

$$\left.\begin{aligned}\mu_2(\varepsilon) &\approx \frac{1}{m}\\ \mu_3(\varepsilon) &\approx \frac{1}{m^2}\\ \mu_4(\varepsilon) &\approx \frac{3}{m^2} + \frac{1}{m^3}\end{aligned}\right\} \qquad (9)$$

Later we will use $t = 1/m$ to simplify the writing of the formulas.

To calculate powers of r, we need

$$\left.\begin{aligned}(1+\varepsilon)^2 &= 1 + 2\varepsilon + \varepsilon^2\\ (1+\varepsilon)^3 &= 1 + 3\varepsilon + 3\varepsilon^2 + \varepsilon^3\\ (1+\varepsilon)^4 &= 1 + 4\varepsilon + 6\varepsilon^2 + 4\varepsilon^3 + \varepsilon^4\end{aligned}\right\} \qquad (10)$$

and

$$\left.\begin{aligned}\frac{1}{1+\varepsilon} &= 1-\varepsilon + \varepsilon^2 - \varepsilon^3 + \varepsilon^4 \ldots\\ \left(\frac{1}{1+\varepsilon}\right)^2 &= 1-2\varepsilon+3\varepsilon^2 - 4\varepsilon^3 + 5\varepsilon^4 \ldots\\ \left(\frac{1}{1+\varepsilon}\right)^3 &= 1 - 3\varepsilon + 6\varepsilon^2 - 10\varepsilon^3 + 15\varepsilon^4 \ldots\\ \left(\frac{1}{1+\varepsilon}\right)^4 &= 1 - 4\varepsilon + 10\varepsilon^2 - 20\varepsilon^3 + 35\varepsilon^4 \ldots\end{aligned}\right\} \qquad (11)$$

Taking expectations, one obtains

$$\left.\begin{aligned}E(1+\varepsilon) &= 1\\ E(1+\varepsilon)^2 &= 1 + \mu_2\\ E(1+\varepsilon)^3 &= 1 + 3\mu_2 + \mu_3\\ E(1+\varepsilon)^4 &= 1 + 6\mu_2 + 4\mu_3 + \mu_4\end{aligned}\right\} \qquad (12)$$

and

$$\left.\begin{aligned}E\left(\frac{1}{1+\varepsilon}\right) &= 1 + \mu_2 - \mu_3 + \mu_4 \ldots\\ E\left(\frac{1}{1+\varepsilon}\right)^2 &= 1 + 3\mu_2 - 4\mu_3 + 5\mu_4 \ldots\\ E\left(\frac{1}{1+\varepsilon}\right)^3 &= 1 + 6\mu_2 - 10\mu_3 + 15\mu_4 \ldots\\ E\left(\frac{1}{1+\varepsilon}\right)^4 &= 1 + 10\mu_2 - 20\mu_3 + 35\mu_4 \ldots\end{aligned}\right\} \qquad (13)$$

If we substitute the approximations (9) and use $t = 1/m$, we obtain

$$\left.\begin{aligned} E(1+\varepsilon)^2 &\approx a_2 = 1+t \\ E(1+\varepsilon)^3 &\approx a_3 = 1 + 3t + t^2 \\ E(1+\varepsilon)^4 &\approx a_4 = 1 + 6t + 7t^2 + t^3 \end{aligned}\right\} \quad (14)$$

and

$$\left.\begin{aligned} E(\tfrac{1}{1+\varepsilon}) &\approx b_1 = 1 + t + 2t^2 + t^3 \\ E(\tfrac{1}{1+\varepsilon})^2 &\approx b_2 = 1 + 3t + 11t^2 + 5t^3 \\ E(\tfrac{1}{1+\varepsilon})^3 &\approx b_3 = 1 + 6t + 35t^2 + 15t^3 \\ E(\tfrac{1}{1+\varepsilon})^4 &\approx b_4 = 1 + 10t + 85t^2 + 35t^3 \end{aligned}\right\} \quad (15)$$

We will later also need b_1^2, b_1^3, and b_1^4 and a_2^2. The approximations up to t^3 are:

$$\left.\begin{aligned} {a_2}^2 &= 1 + 2t + t^2 \\ {b_1}^2 &= 1 + 2t + 5t^2 + 6t^3 \\ {b_1}^3 &= 1 + 3t + 9t^2 + 16t^3 \\ {b_1}^4 &= 1 + 4t + 14t^2 + 32t^3 \end{aligned}\right\} \quad (16)$$

We also will use that for independent random variables x and y

$$E(xy) = E(x)E(y) \quad (17)$$

holds.

Finally, we will use the following relations between the central moments μ_i and non-central moments μ_i':

$$\left.\begin{aligned} \mu_2 &= \mu_2' - (\mu_1')^2 \\ \mu_3 &= \mu_3' - 3\mu_1'\mu_2' + 2(\mu_1')^3 \\ \mu_4 &= \mu_4' - 4\mu_1'\mu_3' + 6(\mu_1')^2\mu_2' - 3(\mu_1')^4 \end{aligned}\right\} \quad (18)$$

4. The First Moment

4.1 Approximation Using Linear Terms Only

If one expands r, considering only the linear terms, one obtains

$$r = 1 + \varepsilon_1 - \varepsilon_2 \tag{19}$$

and, therefore,

$$E(r) = 1. \tag{20}$$

4.2 Approximation Using Terms Up to the Second Order

An expansion up to second order terms is

$$r = (1+\varepsilon_1)(1-\varepsilon_2+\varepsilon_2^2) \tag{21}$$

$$= 1 + \varepsilon_1-\varepsilon_2-\varepsilon_1\varepsilon_2+\varepsilon_2^2.$$

Because independence between the ε_i was assumed, this gives

$$E(r) = 1 + \mu_2(\varepsilon_2). \tag{22}$$

This shows that the expected value of R is greater than (p_1/p_2). Therefore, using this as an estimator for R overestimates the effectiveness 1-R. To assess the magnitude of this bias, we use the approximation (9) and obtain:

$$E(r) \approx 1 + \frac{1}{m_2} . \tag{23}$$

For the situation where each of the two p's is calculated from 20 injuries,

$$E(r) \approx 1.05,$$

for the situation where each is based on 100 injuries,

$$E(r) \approx 1.01.$$

These biases may appear small. However, if, e.g., R = 0.95 was estimated, in the first case the true expected value would be R' = 0.998, and instead of an effectiveness 1-0.95 = 0.05, 1-0.998 = 0.002 should be used in the first case: this means that the expected effect is less than that which one would expect from the biased estimate. In the second case R' = 0.96 is the unbiased expected value and the effectiveness should be 0.04 instead of 0.05, a reduction by 20 percent.

4.3 Approximation Using Terms Up to the Third Order

Using equation (17), we obtain

$$E(r) = E(1+\varepsilon_1)E(\frac{1}{1+\varepsilon_2}) \ , \qquad (24)$$

and from (12) and (15)

$$E(r) = 1+t_2+2t_2^2+t_2^3 \ , \qquad (25)$$

retaining only terms up to the third order. To make estimates of the order of magnitude of the higher order terms, we assume $t_2 = T$ and obtain

$$E(r) = 1+T+2T^2+T^3 \ . \qquad (26)$$

For the first case discussed in 4.2, $m = 20$, $T = 0.05$, one obtains $E(r) = 1.005$, compared with 1.05 in Section 4.2. Whether this difference is important depends on how large R is. For the second case, $m = 100$, $T = 0.01$, the effect is to increase $E(r)$ from 1.01 to 1.0102, which is negligible.

5. The Second Moment

5.1 Approximation Using Linear Terms Only

Using (12), (13) and (17), we obtain

$$E(r^2) = (1+\mu_2(\varepsilon_1))(1+3\mu_2(\varepsilon_2))$$
$$= 1 + \mu_2(\varepsilon_1) + 3\mu_2(\varepsilon_2) \quad (27)$$

when only first order terms in the μ_2 are retained. In order to calculate $\mu_2(r)$, we use (18) which requires

$$\mu_1'(r) = 1+\mu_2(\varepsilon_2) \text{ and} \quad (28)$$

$$(\mu_1'(r))^2 = 1 + 2\mu_2(\varepsilon_2), \quad (29)$$

retaining only the first order terms in the μ_2. Combining (27) and (29) according to (18) gives

$$\mu_2(r) = \mu_2(\varepsilon_1) + \mu_2(\varepsilon_2); \quad (30)$$

the variance of the double ratio is the sum of the variances of the two factors.

5.2 Approximation Using Terms Up to the Third Order

For this approximation we immediately use the approximation (15) and (16). First we have

$$\mu_2'(r) = E(r^2) = E(1+\varepsilon_1)^2 E(\frac{1}{1+\varepsilon_2})^2$$
$$= (1+t_1)(1+3t_2+11t_2^2+5t_2^3) \quad (31)$$
$$= 1 + t_1+3t_2+11t_2^2+5t_2^3+3t_1t_2+11t_1t_2^2+5t_1t_2^3$$

if one retains only terms up to the third order. Since

$$\mu_1' = b_1(\varepsilon_2) \quad (32)$$

(16) gives

$$(\mu_1')^2 = 1+2t_2+5t_2^2+6t_2^3 \quad (33)$$

retaining only terms up to the third order. Combining (31) and (33) according to (18) gives

$$\mu_2 = t_1+t_2+6t_2^2-t_2^3+3t_1t_2+11t_1t_2^2+5t_1t_2^3 \tag{34}$$

The linear terms correspond to the sum of the two $\mu_2(\varepsilon_i)$. The higher order terms are impracticably complicated to be used. Therefore, we use again the special case where all t_i = T and obtain:

$$\begin{aligned} \mu_2(r) &= 2T + 9T^2 + 10T^3 \\ &= 2T(1 + \frac{9}{2}T + 5T^2) \\ &= 2Tf \end{aligned} \tag{35}$$

Since 2T corresponds to the linear terms of $\mu_2(r)$, f is the factor by which it has to be increased. For m = 20 one has f = 1.24, and for m = 100, one has f = 1.05, for m = 500, f = 1.009. Thus, for m = 20, the higher terms are not negligible; for 100 they will usually be so, whereas for 500 they are practically always negligible.

6. <u>The Third Moment</u>

(18) gives for the third moment

$$\mu_3 = \mu_3' - 3(\mu_1'\mu_2') + 2(\mu_1')^3 \tag{36}$$

Using directly (14), (15) and (16) and substituting one T for the t_i, we obtain

$$\begin{aligned} \mu_3'(r) &= (1+3T+T^2)(1+6T+35T^2+15T^3) \\ &= 1 + 9T + 54T^2 + 126T^3 \end{aligned} \tag{37}$$

omitting all terms of higher than third order. Combining

$$\begin{aligned} \mu_2'(r) &= (1+T)(1+3T+11T^2+5T^3) \\ &= 1 + 4T + 14T^2 + 16T^3 \end{aligned} \tag{38}$$

with (26) gives

$$\begin{aligned} \mu_1'(r)\mu_2'(r) &= (1+T+2T^2+T^3)(1+4T+14T^2+16T^3) \\ &= 1 + 5T + 20T^2 + 31T^2 \end{aligned} \tag{39}$$

up to terms of the third order.

Finally, we need

$$(\mu_1')^3 = [1 + T + 2T^2 + T^3]^3 \tag{40}$$

according to (26). This gives

$$(\mu_1')^3 = 1 + 3T + 9T^2 + 16T^3 \tag{41}$$

again omitting terms of higher than third order. Combining (37), (39) and (41) according to (36) gives

$$\mu_3 = 12T^2 + 65T^3. \tag{42}$$

Since μ_3 is not easily interpretable, we will use it only for the Gram-Charlier series expansion to be performed later.

7. The Fourth Moment

$$\mu_4 = \mu_4' - 4(\mu_1'\mu_3') + (6(\mu_1')^2\mu_2') - 3(\mu_1')^4 \tag{43}$$

$$\mu_4' = E(r^4) = E(1+\varepsilon_1)^4 \; E(\frac{1}{1+\varepsilon_2})^4. \tag{44}$$

Using (14) and (15) this becomes:

$$\begin{aligned}\mu_4' &= (1+6T+7T^2+T^3)(1+10T+85T^2+35T^3)\\ &= 1 + 16T + 152T^2 + 616T^3\end{aligned} \tag{45}$$

if omitting terms of higher than third order. Combining (26) and 27) gives

$$\begin{aligned}\mu_1'(r)\mu_3'(r) &= (1+T+2T^2+T^3)(1+9T+54T^2+126T^3)\\ &= 1 + 10T + 65T^2 + 199T^3.\end{aligned} \tag{46}$$

Combining the simplified versions of (31) and (33) gives

$$\begin{aligned}(\mu_1'(r))^2\mu_2'(r) &= (1+4T+14T^2+16T^3)(1+2T+5T^2+6T^3)\\ &= 1 + 6T + 27T^2 + 70T^3.\end{aligned} \tag{47}$$

Finally, by squaring (33), we obtain

$$\begin{aligned}(\mu_1')^4 &= [1 + 2T + 5T^2 + 6T^3]^2\\ &= 1 + 4T + 14T^2 + 32T^3.\end{aligned} \tag{48}$$

Combining (45), (46), (47) and (48) according to (43), we obtain

$$\begin{aligned}\mu_4 = {} & 1 + 16T + 152T^2 + 616T^3\\ & - 4(1+10T+65T^2+199T^3)\\ & + 6(1+6T+27T^2+70T^3)\\ & - 3(1+4T+14T^2+32T^3)\\ = {} & 12T^2 + 144T^3\end{aligned} \tag{49}$$

Since $\mu_2 = 2T+\ldots$, the excess or curtosis $\mu^4/\mu_2{}^2$ approaches 3 for small values of T; this is the value for the normal distribution.

8. Gram-Charlier Series Expansion

8.1 Basic Formulas

A probability density function f(x) can be expanded into a series

$$f(x) = \phi(x)\left(1 + \frac{\mu_3^*}{6} H_3(x) + \frac{\mu_4^*-3}{24} H_4(x) + \ldots\right), \qquad (50)$$

where it is assumed that x is transformed to have mean zero and variance 1; μ_3^* and μ_4^* are the correspondingly transformed third and fourth moments. $H_i(x)$ are the Hermite polynomials

$$\begin{aligned} H_2(x) &= x^2 - 1 \\ H_3(x) &= x^3 - 3x \qquad (51) \\ H_4(x) &= x^4 - 6x^2 + 3 \end{aligned}$$

$\phi(x)$ is the normal probability density.

The cumulative probability function can be expressed as

$$F(x) = \Phi(x) - \phi(x)\left(\frac{\mu_3^*}{6} H_2(x) + \frac{\mu_4^* - 3}{24} H_3(F) + \ldots\right) \qquad (52)$$

where $\Phi(x)$ is the cumulative normal probability distribution.

In standard texts, no remainder terms were found which indicate how accurately a finite series using only a few terms of the infinite series approximates the true distribution.

8.2 Numerical Examples

8.2.1 m = 20

If we assume that both p_i are estimated from 20 injury cases, and that the injury probability is small, we obtain:

First two moments (using linear terms only):

$$\begin{aligned} \mu_1' &= 1 \\ \mu_2 &= \frac{2}{20} = 0.1 \end{aligned} \qquad (53)$$

First two moments (using terms up to the third order):

$$\begin{aligned} \mu_1' &= 1 + \frac{1}{20} + \frac{2}{20^2} + \frac{1}{20^3} = 1.055 \\ \mu_2 &= \frac{2}{20} + \frac{9}{20^2} + \frac{10}{20^3} = 0.124 \end{aligned} \qquad (54)$$

First four moments (using terms up to the third order):

$$\mu_1' = 1.0551$$
$$\mu_2 = 0.1238$$
$$\mu_3 = 0.0381 \qquad \mu_3^* = \mu_3/\sqrt{\mu_2^3} = 0.8747 \tag{55}$$
$$\mu_4 = 0.0480 \qquad \mu_4^* = \mu_4/\mu_2^2 = 3.1318$$

Figure 1 shows the two tails of the cumulative distribution of r. The approximation of the first four moments was calculated from the Gram-Charlier series. It is presumably the closest approximation to the "true" distribution of r. The lower and upper fifth percentiles are at r = 0.55 and r = 1.74.

The approximation of the first two moments using terms up to the third order is based upon a normal distribution with the "true" mean and variance; the lower and upper fifth percentiles are 0.47 and 1.64.

The approximation of the first two moments using linear terms only is based upon a normal distribution with mean 1 and variance = $\varepsilon_1^2+\varepsilon_2^2$. It has the lower and upper fifth percentiles 0.48 and 1.52.

Both of the latter two approximations are unsatisfactory since the effectiveness is 1-R̄; using one of them may result in accepting an effect as significant which is with a fairly high probability due to chance. r = 1.70 would be considered significant at the 96.5 percent level, whereas it is only 94 percent significant with the "true" distribution.

8.22 m = 100

The corresponding results are:

First two moments (using linear terms only):

$$\mu_1' = 1$$
$$\mu_2^{\,2} = \frac{2}{100} = 0.02 \tag{56}$$

First two moments (using terms up to the third order):

$$\mu_1' = 1 + \frac{1}{100} + \frac{2}{100^2} + \frac{1}{100^3} = 1.01$$
$$\mu_2 = \frac{2}{100} + \frac{9}{100^2} + \frac{10}{100^3} = 0.021 \tag{57}$$

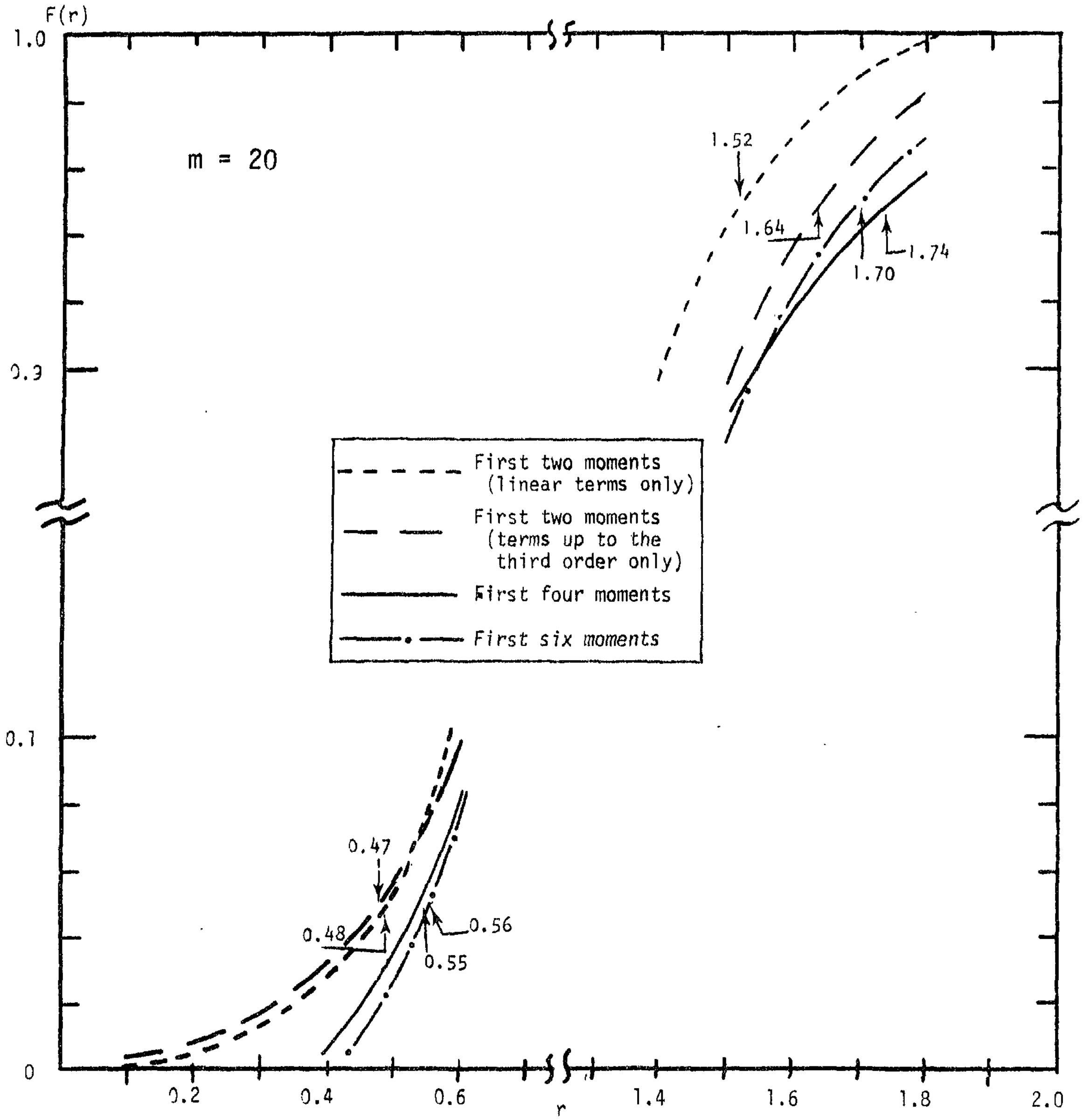

Figure 1. Two tails of the cumulative distribution of r depicting the lower and upper fifth percentiles (m = 20).

First four moments (using terms up to the third order):

$$\mu_1' = 1.0102$$

$$\mu_2 = 0.0209$$

$$\mu_3 = 0.0013 \qquad \mu_3^* = \mu_3/\sqrt{\mu_2^3} = 0.4302 \tag{58}$$

$$\mu_4 = 0.0013 \qquad \mu_4^* = \mu_4/\mu_2^2 = 2.9761$$

Figure 2 shows the tails of the corresponding distribution. Here, at the left tail, the differences between two of the three distributions are negligible. At the right tail, the difference between the approximations of the first four and the first two moments (using terms up to the third order) is negligible; the difference between them and the approximation of the first two moments using linear terms only may just be important in some cases.

8.3 Approximate Estimation of Confidence Limits

To calculate the entire distribution or part of it to determine for which x', $F(x') = 1-\alpha$ holds is relatively time-consuming. An approximation may be sufficient. We write

$$F(x) = F(x_o) + F'(x_o)(x - x_o) \tag{59}$$

We now chose x_o so that $\phi(x_o) = 1-\alpha$. x_o is the derived confidence limit for the normal distribution. We define x' as the confidence limit for the studied distribution: $F(x') = 1-\alpha$. Then we have

$$x' - x_o = \frac{1-\alpha-F(x_o)}{F'(x_o)} . \tag{60}$$

(52) gives

$$\begin{aligned} F(x_o) &= \phi(x_o) - \Phi(x_o)\left(\frac{\mu_3^*}{6} H_2(x_o) + \frac{\mu_4^*-3}{24} H_2(x_o)\right) \\ &= 1-\alpha-\Phi(x_o)\left(\frac{\mu_3^*}{6} H_2(x_o) + \frac{\mu_4^*-3}{24} H_3(x_o)\right) \end{aligned} \tag{61}$$

Since $F'(x) = f(x)$, we can combine (60), (61) and (50) and obtain

$$x'-x_o = \frac{\frac{\mu_3^*}{6} H_2(x_o) + \frac{\mu_4^*-3}{24} H_3(x_o)}{1 + \frac{\mu_3^*}{6} H_3(x_o) + \frac{\mu_4^*-3}{24} H_4(x_o)} . \tag{62}$$

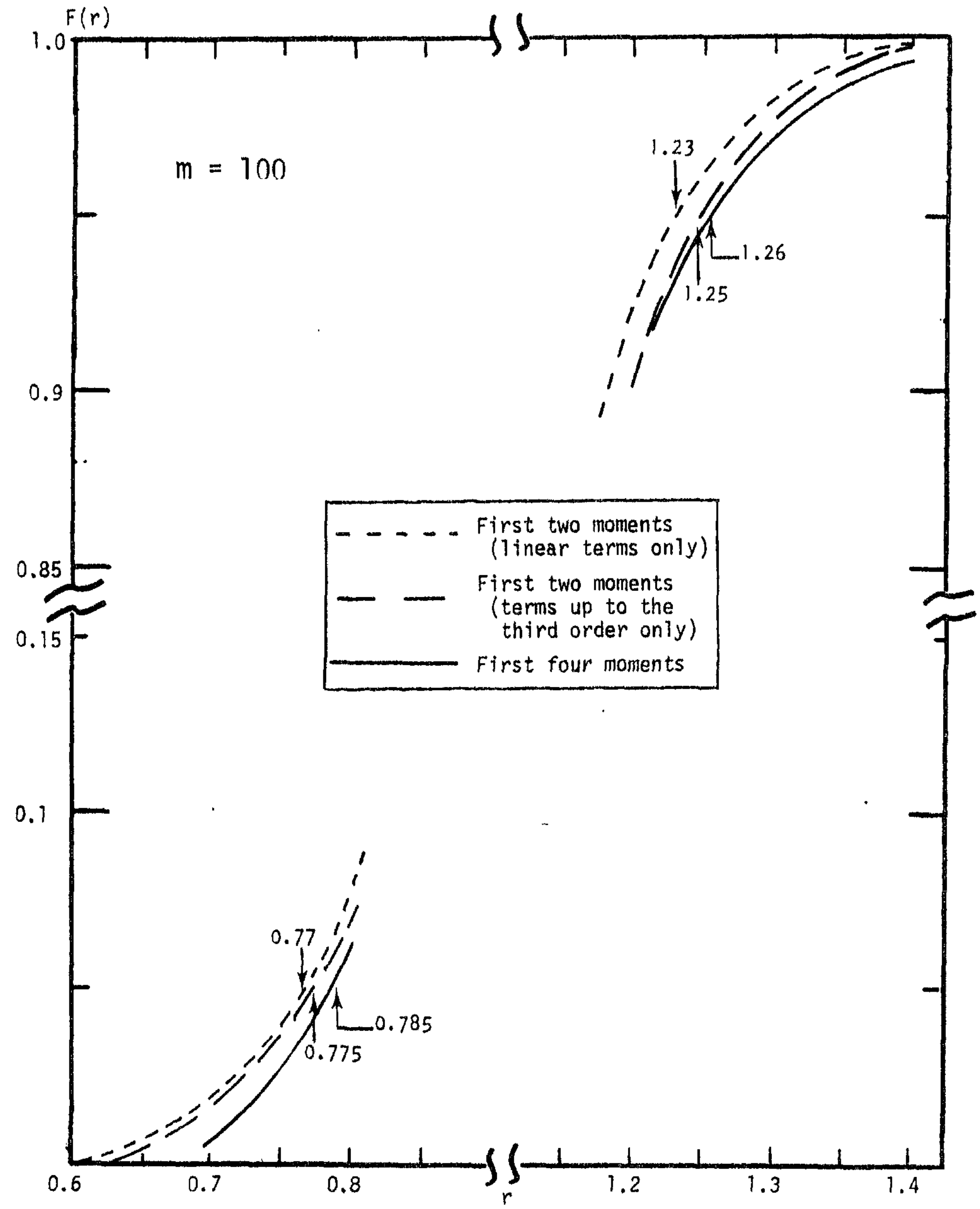

Figure 2. Two tails of the cumulative distribution of r depicting the lower and upper fifth percentiles (m = 100).

If we use $\alpha = 0.05$ as an example, $x_o = 1.64$, and we have $H_2(x_o) = 1.690$, $H_3(x_o) = -0.509$, $H_4(x_o) = -5.904$. Therefore,

$$x' - 1.64 = \frac{0.282\mu_3^* - 0.021(\mu_4^*-3)}{1-0.085\mu_3^* - 0.246(\mu_4^*-3)} . \tag{63}$$

Thus, one can calculate the approximate upper 95 percent confidence limit for any distribution, where the μ_3^* (skewness) and μ_4^* (excess, curtosis) are given.

9. Conclusions and Recommendations

The numerical examples suggest that for $m > 100$ one can use the normal approximation, preferably corrected for the bias in $\bar{r}$; but for $m > 400$ or 500, this is definitely not necessary.

For $m = 20$, the normal approximation, even if corrected for bias and with an inflated ε, is definitely inadequate. Somewhere between 20 and 100 is an m where it becomes sufficient to correct r and inflate ε. The approximations were derived for "small" values of the π_i. That means that the p_i have highly skewed distributions. For larger π_i, the distributions are less skewed; for $\pi_i = 0.5$ they are symmetric. Therefore, one can expect that the normal approximations will be sufficient for smaller values of m than suggested above, if the π_i are not small.

For small values of m one should proceed as follows:

1) Calculate $\mu_i(\varepsilon_j)$.

2) Calculate $E(\frac{1}{1+\varepsilon_2})^k$; $E(1+\varepsilon_1)^k$.

3) Calculate $E(r^k)$.

4) Calculate $\mu_k(r)$.

5) Calculate $\mu_3^*(r)$ and $\mu_4^*(r)$.

6) Apply equation (62) for the desired confidence limits.

Elaboration:

1) Calculate $\mu_i(\varepsilon_j)$

   i = order of moment, j index of p_j in $\frac{p_1}{p_2}$

2) Using equation (8), calculate $E(\frac{1}{1+\varepsilon_2})^k$; $E(1+\varepsilon_1)^k$.

   Assume that only the second order

   approximation will be used: k = 1, 2.

$$E(\frac{1}{1+\varepsilon_2})^2 = 1 + \mu_2(\varepsilon_2) - \mu_3(\varepsilon_2) + \mu_4(\varepsilon_2)$$

$$E(\frac{1}{1+\varepsilon_2})^2 = 1 + 3\mu_2(\varepsilon_2) - 4\mu_3(\varepsilon_2) + 5\mu_4(\varepsilon_2)$$

$$E(1+\varepsilon_1) = 1$$

$$E(1+\varepsilon_2)^2 = 1 + \mu_2(\varepsilon_2)$$

3) Calculate $E(r^k) = E(1+\varepsilon_1)^k \; E(\frac{1}{1+\varepsilon_2})^k$

$\mu'_k(r) = E(r^k)$.

4) Calculate $\mu_2(r)$. Use equation (18).

Calculate $\mu_k(R) = (\frac{\pi_1}{\pi_2})\mu_k(r)$.

Calculate $\mu'_k(R) = (\frac{\pi_1}{\pi_2})\mu'_k(r)$.

5) Omit for this level approximation.

6) For $m_j > 100$, use a normal distribution with $\mu'_1(R)$ and $\mu_2(R)$.