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Papers on Adult Seat Belts—Effectiveness and Use

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16. Abstract

The eight papers in this volume describe analyses of the effectiveness and use of adult seat belts, based on traffic accident data. All eight were written between January 1984 and May 1988. The topics addressed include front seat belt effectiveness (estimated separately for states with vs without a seat belt use law, for drivers vs right-front seat passengers, for occupants of cars vs pickup trucks, and by crash direction and accident year), rear seat belt effectiveness, and issues in estimating belt effectiveness from accident data. The principal accident data sources are the Fatal Accident Reporting System (FARS), the National Crash Severity Study (NCSS), and the National Accident Sampling System (NASS).

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FOREWORD

This volume contains eight papers about adult seat belts written between January 1984 and May 1988. Over these four years, the majority of states have passed belt laws, and belt use has greatly increased. The earlier problems in belt effectiveness evaluation included the infrequency of belt use (sample size) and the low priority of belt use reporting (missing data and the resulting biases). These problems have been largely replaced by questions about the legal implications and increased social acceptability of belt use (reporting biases) and identification of areas for further improvements. These eight papers span this shift in emphasis.

"Seat Belt Effectiveness Estimates Using Data Adjusted for Damage Type" (January 1984) describes a method for compensating for a natural bias in the accident data -- accidents involving seat belt wearers tend to be less severe (in terms of crash severity) than accidents involving non-wearers. Failing to account for this difference can produce overestimates of belt effectiveness. The method described here was used (with additional data) in the agency's evaluation of its frontal protection standard.

"Note on Rear Seat Belt Use and Usefulness Estimated from Automated Accident Data" (March 1986) describes the few available national data on rear seat belts in towaway accidents. An evaluation of rear seat belt effectiveness is seriously hampered by low rates of rear seat occupancy and belt use. The results were used in interpreting the findings of a study of rear seat belt performance in frontal accidents, conducted by the National Transportation Safety Board.

"Note on the Bias Introduced by an Injury Threshold on Estimates Made for Crashworthiness Research" (April 1986) demonstrates that seat belt effectiveness cannot be evaluated from injury accidents alone. The exclusion of noninjury accidents from a data file causes a serious underestimation of seat belt effectiveness. This point was used in defining the scope of the agency's accident data collection efforts.

"Note on Belt Effectiveness Estimates from Fatal Accidents -- Comparison by Mandatory Belt Use Law Coverage" (July 1986) explores the possibility that state belt use laws may introduce a bias in belt use reporting in fatal accidents. The review shows a slightly higher belt effectiveness estimate produced from the belt law states, as compared to the nonlaw states. This finding is consistent with the suggestion of bias, but the magnitude of the difference was small enough to encourage further analytical use of reported belt use.

"Lap and Shoulder Belt Effectiveness by Fatal Accident Crash Direction" (October 1986) provides separate estimates for rollovers and for front, side, and rear nonrollover crashes. The results indicate that belts are particularly effective in rollovers and in frontal crashes. This finding is consistent with results from a previous study that, because of sample size limitations, could not draw strong conclusions from the low frequency of serious injury among those belted in rollover accidents.

"Belt Effectiveness in Fatal Accidents" (November 1986) provides annual estimates of belt effectiveness from fatal accident data. The results indicate that the driver seat belt may be more effective in preventing fatality than is that of the right-front passenger. The overall estimate of effectiveness is consistent with previous agency estimates.

"Are Belts More Effective for Drivers or for Right-Front Passengers?" (April 1987) explores the finding in the previously-mentioned study in light of British reports of greater passenger injury reduction following implementation of their seat belt law. The explanation for the discrepancy appears to lie in two methodological differences: whether fatality or injury reduction is being evaluated, and whether belt or belt law effectiveness is being evaluated. The implication is that what is being compared greatly influences the results of the comparison.

"Belt Effectiveness in Pickup Trucks and Passenger Cars by Crash Direction and Accident Year" (May 1988) suggests that belts may be even more effective in pickup trucks than in cars, especially in rollovers. The comparison by crash direction suggests that whether the occupant is seated on the same side as, or on the opposite side from, a side impact is very important in cars, but not in pickup trucks. The results can be used to understand how belts save lives, with the ultimate goal of increasing their effectiveness and use.

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Using Data Adjusted for Damage Type
January 1984

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Summary

The evaluation of the effectiveness of restraints in preventing fatality and reducing injury severity is confounded by differences in the crash conditions experienced by unrestrained, lap-belted, and lap-and-shoulder-belted car occupants. These differences introduce a bias into the comparisons of fatality and injury rates. To make the comparisons fairer, it is necessary to account for the differences in crash conditions by restraint use. In this paper two elements of the Collision Deformation Classification, area of damage and extent zone for the damage, were used to describe the crash conditions.

The data were adjusted in three different ways to reflect the experiences of three different groups of victims. Because restraints are more effective in some types of crashes than in others, this led to three different estimates of overall restraint effectiveness. These three estimates should be interpreted as addressing the following three questions about restraint effectiveness.

1. How useful are restraints for the people who now use them? (Adjust the data to reflect the crash conditions of restrained occupants.)

2. How useful would restraints be if everyone used them? (Adjust the data to reflect the overall crash conditions.)

3. How useful would restraints be for people who do not now use them? (Adjust the data to reflect the crash conditions of unrestrained occupants.)

The results are shown in the Summary Table.

Summary Table

Injury Level	Belt Effectiveness: Lap and Shoulder	Belt Effectiveness: Lap Only
Any Injury		
unadjusted	20%	22%
adjusted:		
to restrained	16%	17%
to overall	16%	16%
to unrestrained	16%	15%
Moderate Injury		
unadjusted	59%	49%
adjusted:		
to restrained	53%	39%
to overall	48%	30%
to unrestrained	47%	30%
Serious Injury		
unadjusted	54%	49%
adjusted:		
to restrained	44%	34%
to overall	38%	28%
to unrestrained	37%	28%
Fatality		
unadjusted	60%	47%
adjusted:		
to restrained	52%	21%
to overall	39%	22%
to unrestrained	38%	22%

Restrained occupants are less frequently killed and less seriously injured because

1) restraints afford protection against injury, and

2) restrained occupants tend to be in less serious accidents.

The purpose of the adjustments is to remove the effect of the second point in order to better evaluate the effect of the first point. As can be seen in the table, the adjustments lower the estimate of effectiveness in each case.

The differences between the adjustment methods reflect one other point:

3) restraints are less useful in the more serious accidents, where massive intrusion occurs.

The result is that if people who are currently unrestrained began to use restraints (but did not otherwise change their driving practices), the percentage reduction in fatality and injury would be slightly less than that observed for current restraint users. However, the benefits would still be large - based on these data, in the neighborhood of 40 percent for moderate, serious, and fatal injury.

Method

Several data files were used together after recoding variables for consistency. These files are

1) the National Crash Severity Study (NCSS);

2) the data collected by the former-NCSS teams using the forms and protocols of the National Accident Sampling System (NCSS-NASS); and

3) the National Accident Sampling System (NASS) data for
   a) the completed and officially released years 1979, 1980, and 1981;
   b) the completed but not yet officially released year 1982; and
   c) the partial year 1983, as available in early December 1983.

From these data, cars were selected if they were towed for damage received in the accident and had the damage type (in terms of the Collision Deformation Classification) recorded. The occupants of these cars were included in this study if they were in the front seat, known to be at least 10 years old, and were known to be either unrestrained, lap-belted, or lap-and-shoulder belted. From the combined data, there were a total of 34,077 occupants who satisfied these requirements.

The data in the various files were collected using different sampling plans, but each plan was designed to collect a larger portion of serious accidents than occur naturally. To account for the sampling plans, the data must be weighted before injury frequencies can be calculated. The method used was adjustment by Ockham weights. This scheme has been documented and used in previous analysis (references 1 and 2). The Ockham weights represent the minimum weighting necessary to adjust for the differential sampling by accident type -- it includes no adjustments for other sampling factors, such as geographical considerations.

Four injury variables were defined in terms of fatality and the Abbreviated Injury Scale (AIS). The variables are

1) Fatal - yes
   - no or unknown;

2) Serious - fatality or AIS 3 through 5
   - no or unknown;

3) Moderate - fatality or AIS 2 through 5
   - no or unknown; and

4) Injury - fatality or known to be injured
   - no or unknown.

Results

Tables 1 through 4 (Appendix) show the injury rates for these four injury thresholds for all people included in the study, weighted by the Ockham factors. The injury rates for restrained occupants are much lower than these observed for unrestrained occupants. When the rates are compared by the formula

$$\frac{\text{unrestrained rate - restrained rate}}{\text{unrestrained rate}}$$

lap belt users are estimated to have about 50 percent fewer moderate, serious, and fatal injuries. Lap-and-shoulder belt users had 60 percent fewer of these injuries. The difference for the lowest threshold (any injury level) was about 20 percent for each type of restraint system.

Some of this difference is attributable to the restraint system itself. However, Tables 5 through 7 show that in these data, the distribution of damage type (area of damage and extent zone for the damage) differs by restraint use. To correct for this, the number of unrestrained occurrences within each category of damage type was adjusted to the number of lap-belted (and, separately, lap-and-shoulder belted) occupants. (The automated procedure is included in the Appendix.)

The injury rate comparisons after adjustment to the restrained experience are shown in Tables 8 through 11 (lap-and-shoulder belts) and Tables 12 through 15 (lap belts only). The adjustment reduces the apparent advantage of the lap-and-shoulder system slightly (4 to 10 percentage points). The effect for lap belts is much larger (5 to 26 percentage points). The cars in which lap belts are available (which tend to be older and heavier) appear to be in accidents that differ from those experienced by cars with either unrestrained or lap-and-shoulder belted occupants.

Tables 16 and 17 show that after adjustment for damage type, some diiferences remain that are relevant to injury severity. The averages for lap-and-shoulder belted versus unrestrained occupants are as follows.

Data Adjusted for Damage Area and Extent
of Lap-and-Shoulder Belt Users

	Lap and Shoulder	None
Vehicle weight (100s of pounds)	30.97	33.20
Crash severity, delta V (kilometers per hour)	17.25	18.54
Occupant age (years)	33.43	30.95

The lap-and-shoulder belted occupants incur lower crash severity, but they are also older and in smaller cars. A similar pattern was found for lap belt wearers.

Data Adjusted for Damage Area and Extent
of Lap Belt Users

	Lap Belt	None
Vehicle weight (100s of pounds)	33.78	33.33
Crash severity, delta V (kilometers per hour)	16.61	18.46
Occupant age (years)	36.07	31.10

There is no clear bias apparent after controlling for damage type. Differences remain, but some imply greater risk for restraint users, and some imply less.

When the data were adjusted to the overall accident experience (Tables 18-25), the effectiveness estimates are reduced further. The average differences in other relevant factors are shown in Tables 26 and 27. Adjusting to just unrestrained occupants (Tables 28-37) does not have much further effect because most occupants (in the overall summaries) are unrestrained.

Discussion

Even in the adjusted data, the restrained and unrestrained groups do not match on all important factors. However, the differences at least partially cancel each other. Unrestrained occupants are

1) at greater risk because the crash forces they experience are greater, but

2) at less risk because they are younger and in larger cars.

Controlling for one of these factors, magnitude of the crash forces, would further decrease the estimates of restraint effectiveness. This control is not recommended because it ignores

1) specific types of crashes for which the magnitude of the crash forces is not known (for example, rollovers and sideswipes) and

2) the effects of car size (in terms of intrusion, occupant space, and crush characteristics) on injury severity.

Delta V is a measure of the change in vehicle velocity experienced during the crash. The data were separated into cases for which delta V is known and cases for which delta V is unknown, and estimates of restraint effectiveness were calculated (using the method of adjusting to the restrained damage type experience). The results (Tables 38-53) show that restraints are especially effective in accidents for which delta V cannot be calculated. Thus, controlling for delta V would produce underestimates of effectiveness because of the bias in the missing delta V data. The comparison by presence of delta V data is presented in the following table.

Data Adjusted for Damage Area and Extent
of Restraint Users

Injury Level	Belt Effectiveness: Lap and Shoulder	Belt Effectiveness: Lap Only
Any Injury		
delta V known	17%	15%
delta V unknown	14%	20%
Moderate		
delta V known	44%	42%
delta V unknown	59%	34%
Serious		
delta V known	25%	42%
delta V unknown	55%	24%
Fatal		
delta V known	21%	14%
delta V unknown	65%	33%

The reader is cautioned on one other point: any adjustment for crash severity implies an assumption about the relative effects of crash force, intrusion, ejection, occupant compartment space dimensions, and personal risk factors. Because these effects are not yet fully understood, there is no definitive adjustment process.

References

1. Partyka, S.; "A Method for Using NASS Data Based upon Ockham's Razor"; NCSA, NHTSA; Washington, D.C.; September 1982.

2. Partyka, S.; "State Injury Estimates Based upon a Synthesis of National Accident Data"; NCSA, NHTSA; Washington, D.C.; September 1983.

Appendix

Table 1: Occurrences of Fatality by Restraint Use

FATAL FREQUENCY PERCENT COL PCT	RESTRAIN L&S	LAP	NONE	TOTAL
NO	7357 5.88 99.57	3834 3.07 99.43	112608 90.03 98.92	123799 98.98
YES	32 0.03 0.43	22 0.02 0.57	1224 0.98 1.08	1278 1.02
TOTAL	7389 5.91	3856 3.08	113833 91.01	125077 100.00

Table 2: Occurrences of Serious Injury by Restraint Use

SERIOUS FREQUENCY PERCENT COL PCT	RESTRAIN L&S	LAP	NONE	TOTAL
NO	7243 5.79 98.02	3772 3.02 97.82	108988 87.14 95.74	120003 95.94
YES	146 0.12 1.98	84 0.07 2.18	4844 3.87 4.26	5074 4.06
TOTAL	7389 5.91	3856 3.08	113833 91.01	125077 100.00

Table 3: Occurrences of Moderate Injury by Restraint Use

MODERATE / FREQUENCY / PERCENT / COL PCT	RESTRAIN: L&S	LAP	NONE	TOTAL
NO	7085 5.66 95.90	3661 2.93 94.93	102477 81.93 90.02	113223 90.52
YES	303 0.24 4.10	195 0.16 5.07	11356 9.08 9.98	11854 9.48
TOTAL	7389 5.91	3856 3.08	113833 91.01	125077 100.00

Table 4: Occurrences of Any Injury by Restraint Use

INJURY / FREQUENCY / PERCENT / COL PCT	RESTRAIN: L&S	LAP	NONE	TOTAL
NO	4423 3.54 59.86	2350 1.88 60.95	56626 45.27 49.74	63399 50.69
YES	2966 2.37 40.14	1506 1.20 39.05	57207 45.74 50.26	61678 49.31
TOTAL	7389 5.91	3856 3.08	113833 91.01	125077 100.00

Table 5: Damage Type for Lap-and-Shoulder Belt Users

V_EXTENT V_AREA

FREQUENCY PERCENT COL PCT	BACK	FRONT	SIDE	TOP	UNDER	TOTAL
1	107 1.45 19.69	1906 25.80 46.03	385 5.22 17.65	15 0.20 3.62	57 0.77 53.27	2470 33.44
2	224 3.03 41.32	1481 20.05 35.77	937 12.68 42.91	35 0.47 8.44	50 0.68 46.73	2728 36.92
3	123 1.66 22.58	353 4.77 8.51	755 10.22 34.59	266 3.60 64.07	0 0.00 0.00	1496 20.25
4	30 0.41 5.55	94 1.27 2.26	86 1.17 3.96	32 0.43 7.65	0 0.00 0.00	242 3.28
5	18 0.24 3.32	44 0.60 1.06	12 0.17 0.56	41 0.56 9.96	0 0.00 0.00	116 1.56
6	26 0.35 4.81	55 0.75 1.33	3 0.04 0.14	7 0.09 1.69	0 0.00 0.00	91 1.23
7	5 0.07 0.94	60 0.82 1.46	4 0.05 0.18	19 0.26 4.58	0 0.00 0.00	89 1.20
8	3 0.04 0.55	19 0.26 0.46	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	22 0.30
9	7 0.09 1.23	128 1.74 3.10	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	135 1.83
TOTAL	543 7.34	4141 56.04	2183 29.55	415 5.61	107 1.45	7389 100.00

Table 6: Damage Type for Lap-Belt Users

V_EXTENT / FREQUENCY / PERCENT / COL PCT	V_AREA: BACK	FRONT	SIDE	TOP	UNDER	TOTAL
1	141	1045	201	1	24	1412
	3.67	27.09	5.22	0.03	0.62	36.63
	47.48	47.44	16.80	0.89	52.17	
2	73	793	528	10	22	1425
	1.89	20.56	13.68	0.26	0.57	36.96
	24.52	36.00	44.05	8.89	47.83	
3	45	227	416	56	0	744
	1.17	5.89	10.78	1.46	0.00	19.30
	15.11	10.31	34.70	50.21	0.00	
4	10	59	39	15	0	123
	0.26	1.53	1.02	0.39	0.00	3.20
	3.36	2.68	3.28	13.34	0.00	
5	16	38	14	26	0	95
	0.42	0.99	0.36	0.67	0.00	2.45
	5.46	1.74	1.17	23.12	0.00	
6	5	13	0	4	0	22
	0.13	0.34	0.00	0.10	0.00	0.58
	1.73	0.60	0.00	3.56	0.00	
7	0	9	0	0	0	9
	0.00	0.23	0.00	0.00	0.00	0.23
	0.00	0.41	0.00	0.00	0.00	
8	6	3	0	0	0	9
	0.16	0.08	0.00	0.00	0.00	0.23
	2.01	0.14	0.00	0.00	0.00	
9	1	15	0	0	0	16
	0.03	0.39	0.00	0.00	0.00	0.41
	0.34	0.68	0.00	0.00	0.00	
TOTAL	298	2202	1198	112	46	3856
	7.72	57.10	31.06	2.92	1.19	100.00

Table 7: Damage Type for those Unrestrained

V_EXTENT V_AREA

FREQUENCY / PERCENT / COL PCT	BACK	FRONT	SIDE	TOP	UNDER	TOTAL
1	1291 1.13 19.27	26249 23.06 37.91	3694 3.25 11.84	206 0.18 4.12	788 0.69 47.01	32230 28.31
2	2168 1.90 32.35	27082 23.79 39.11	11385 10.00 36.48	529 0.46 10.56	735 0.65 43.82	41898 36.81
3	1213 1.07 18.10	8908 7.83 12.87	13462 11.83 43.14	2657 2.33 53.04	82 0.07 4.91	26322 23.12
4	821 0.72 12.25	2400 2.11 3.47	1941 1.70 6.22	826 0.73 16.49	43 0.04 2.57	6031 5.30
5	638 0.56 9.52	1240 1.09 1.79	468 0.41 1.50	459 0.40 9.16	0 0.00 0.00	2805 2.46
6	403 0.35 6.01	1056 0.93 1.53	119 0.10 0.38	241 0.21 4.81	5 0.00 0.30	1825 1.60
7	83 0.07 1.24	595 0.52 0.86	57 0.05 0.18	60 0.05 1.20	0 0.00 0.00	796 0.70
8	29 0.03 0.43	358 0.31 0.52	13 0.01 0.04	32 0.03 0.63	0 0.00 0.00	431 0.38
9	55 0.05 0.82	1348 1.18 1.95	68 0.06 0.22	0 0.00 0.00	23 0.02 1.39	1495 1.31
TOTAL	6702 5.89	69237 60.82	31207 27.41	5009 4.40	1677 1.47	113833 100.00

Table 8: Fatalities Adjusted to Lap-and-Shoulder Damage Type

FATAL — RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	7357 49.79 99.57	0 . .	7321 49.54 99.09	14678 99.33
YES	32 0.21 0.43	0 . .	67 0.45 0.91	99 0.67
TOTAL	7389 50.00	. .	7388 50.00	14777 100.00

Table 9: Serious Injury Adjusted to Lap-and-Shoulder Damage Type

SERIOUS — RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	7243 49.01 98.02	0 . .	7126 48.22 96.45	14368 97.24
YES	146 0.99 1.98	0 . .	262 1.77 3.55	408 2.76
TOTAL	7389 50.00	. .	7388 50.00	14777 100.00

Table 10: Moderate Injury Adjusted to Lap-and-Shoulder Damage Type

MODERATE — RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	7085 47.95 95.90	0 . .	6748 45.67 91.35	13834 93.62
YES	303 2.05 4.10	0 . .	639 4.33 8.65	943 6.38
TOTAL	7389 50.00	. .	7388 50.00	14777 100.00

Table 11: Any Injury Adjusted to Lap-and-Shoulder Damage Type

INJURY — RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	4423 29.93 59.86	0 . .	3874 26.22 52.43	8297 56.15
YES	2966 20.07 40.14	0 . .	3514 23.78 47.57	6480 43.85
TOTAL	7389 50.00	. .	7388 50.00	14777 100.00

Table 12: Fatalities Adjusted to Lap-Belt Only Damage Type

FATAL — RESTRAIN

FREQUENCY PERCENT COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	3834 49.72 99.43	3827 49.63 99.27	7661 99.35
YES	0 . .	22 0.29 0.57	28 0.36 0.73	50 0.65
TOTAL	. .	3856 50.00	3855 50.00	7711 100.00

Table 13: Serious Injury Adjusted to Lap-Belt Only Damage Type

SERIOUS — RESTRAIN

FREQUENCY PERCENT COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	3772 48.91 97.82	3728 48.34 96.68	7500 97.25
YES	0 . .	84 1.09 2.18	128 1.66 3.32	212 2.75
TOTAL	. .	3856 50.00	3855 50.00	7711 100.00

Table 14: Moderate Injury Adjusted to Lap-Belt Only Damage Type

MODERATE — RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	0	3661	3535	7195
	.	47.47	45.83	93.30
	.	94.93	91.68	
YES	0	195	321	516
	.	2.53	4.16	6.70
	.	5.07	8.32	
TOTAL	.	3856	3855	7711
	.	50.00	50.00	100.00

Table 15: Any Injury Adjusted to Lap-Belt Only Damage Type

INJURY — RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	0	2350	2039	4390
	.	30.48	26.45	56.93
	.	60.95	52.90	
YES	0	1506	1816	3322
	.	19.53	23.55	43.07
	.	39.05	47.10	
TOTAL	.	3856	3855	7711
	.	50.00	50.00	100.00

Table 16: Averages for the Data Adjusted to Lap-and-Shoulders Users

RESTRAIN	VEH_WT	VEH_MY	DELTAV	OCC_AGE
L&S	30.9744	75.9772	17.2520	33.4259
LAP	.	.	.	.
NONE	33.2000	73.0067	18.5372	30.9544

Table 17: Averages for the Data Adjusted to Lap-Belt Only Users

RESTRAIN	VEH_WT	VEH_MY	DELTAV	OCC_AGE
L&S	.	.	.	.
LAP	33.7762	71.0984	16.[illegible]093	36.0745
NONE	33.3293	72.9778	18.4602	31.1033

Table 18: Lap-and-Shoulder Fatalities Adjusted to Overall Damage Type

FATAL RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	124019 49.69 99.37	0 . .	123497 49.48 98.97	247516 99.17
YES	790 0.32 0.63	0 . .	1290 0.52 1.03	2080 0.83
TOTAL	124809 50.00	. .	124787 50.00	249596 100.00

Table 19: Lap-and-Shoulder Serious Injury Adjusted to Overall Damage Type

SERIOUS RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	121570 48.71 97.40	0 . .	119598 47.92 95.84	241168 96.62
YES	3239 1.30 2.60	0 . .	5189 2.08 4.16	8428 3.38
TOTAL	124809 50.00	. .	124787 50.00	249596 100.00

Table 20: Lap-and-Shoulder Moderate Injury Adjusted to Overall Damage Type

MODERATE RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	118414 47.44 94.88	0 . .	112550 45.09 90.19	230964 92.54
YES	6396 2.56 5.12	0 . .	12237 4.90 9.81	18632 7.46
TOTAL	124809 50.00	. .	124787 50.00	249596 100.00

Table 21: Lap-and-Shoulder Any Injury Adjusted to Overall Damage Type

INJURY RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	72492 29.04 58.08	0 . .	62451 25.02 50.05	134942 54.06
YES	52318 20.96 41.92	0 . .	62337 24.97 49.95	114655 45.94
TOTAL	124810 50.00	. .	124788 50.00	249597 100.00

Table 22: Lap-Belt Only Fatalities Adjusted to Overall Damage Type

FATAL RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	123509 49.62 99.24	123222 49.51 99.02	246731 99.13
YES	0 . .	949 0.38 0.76	1214 0.49 0.98	2163 0.87
TOTAL	. .	124459 50.00	124436 50.00	248894 100.00

Table 23: Lap-Belt Only Serious Injury Adjusted to Overall Damage Type

SERIOUS RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	120807 48.54 97.07	119358 47.96 95.92	240165 96.49
YES	0 . .	3652 1.47 2.93	5078 2.04 4.08	8729 3.51
TOTAL	. .	124459 50.00	124436 50.00	248895 100.00

Table 24: Lap-Belt Only Moderate Injury Adjusted to Overall Damage Type

MODERATE RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	0	115988	112350	228339
	.	46.60	45.14	91.74
	.	93.19	90.29	
YES	0	8471	12086	20556
	.	3.40	4.86	8.26
	.	6.81	9.71	
TOTAL	.	124459	124436	248895
	.	50.00	50.00	100.00

Table 25: Lap-Belt Only Any Injury Adjusted to Overall Damage Type

INJURY RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	0	72014	62369	134383
	.	28.93	25.06	53.99
	.	57.86	50.12	
YES	0	52445	62068	114513
	.	21.07	24.94	46.01
	.	42.14	49.88	
TOTAL	.	124459	124437	248896
	.	50.00	50.00	100.00

Table 26: Lap-and-Shoulder Averages for the Data Adjusted to Overall Damage Type

RESTRAIN	VEH_WT	VEH_MY	DELTAV	OCC_AGE
L&S	31.0229	75.9214	18.3418	33.3006
LAP	.	.	.	.
NONE	33.1985	72.9564	19.8877	30.7706

Table 27: Lap-Belt Only Averages for the Data Adjusted to Overall Damage Type

RESTRAIN	VEH_WT	VEH_MY	DELTAV	OCC_AGE
L&S	.	.	.	.
LAP	33.5672	71.2373	18.0285	35.4403
NONE	33.2051	72.9542	19.8604	30.7759

Table 28: Lap-and-Shoulder Fatalities Adjusted to Unrestrained Damage Type

FATAL RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	112822 49.67 99.35	0 . .	112370 49.47 98.95	225193 99.15
YES	742 0.33 0.65	0 . .	1195 0.53 1.05	1937 0.85
TOTAL	113564 50.00	. .	113565 50.00	227129 100.00

Table 29: Lap-and-Shoulder Serious Injury Adjusted to Unrestrained Damage Type

SERIOUS RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	110548 48.67 97.34	0 . .	108767 47.89 95.77	219315 96.56
YES	3016 1.33 2.66	0 . .	4799 2.11 4.23	7815 3.44
TOTAL	113564 50.00	. .	113566 50.00	227130 100.00

Table 30: Lap-and-Shoulder Moderate Injury Adjusted to Unrestrained Damage Type

MODERATE RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	107633 47.39 94.78	0 . .	102289 45.04 90.07	209922 92.42
YES	5931 2.61 5.22	0 . .	11277 4.96 9.93	17208 7.58
TOTAL	113564 50.00	. .	113566 50.00	227130 100.00

Table 31: Lap-and-Shoulder Any Injury Adjusted to Unrestrained Damage Type

INJURY RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	65769 28.96 57.91	0 . .	56548 24.90 49.79	122317 53.85
YES	47796 21.04 42.09	0 . .	57018 25.10 50.21	104813 46.15
TOTAL	113565 50.00	. .	113566 50.00	227131 100.00

Table 32: Lap-Belt Only Fatalities Adjusted to Unrestrained Damage Type

FATAL — RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	0	112373	112122	224494
	.	49.61	49.50	99.12
	.	99.23	99.01	
YES	0	873	1124	1996
	.	0.39	0.50	0.88
	.	0.77	0.99	
TOTAL	.	113245	113246	226491
	.	50.00	50.00	100.00

Table 33: Lap-Belt Only Serious Injury Adjusted to Unrestrained Damage Type

SERIOUS — RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	0	109873	108550	218423
	.	48.51	47.93	96.44
	.	97.02	95.85	
YES	0	3372	4696	8068
	.	1.49	2.07	3.56
	.	2.98	4.15	
TOTAL	.	113245	113246	226491
	.	50.00	50.00	100.00

Table 34: Lap-Belt Only Moderate Injury Adjusted to Unrestrained Damage Type

MODERATE RESTRAIN

FREQUENCY PERCENT COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	105405 46.54 93.08	102107 45.08 90.16	207512 91.62
YES	0 . .	7840 3.46 6.92	11139 4.92 9.84	18979 8.38
TOTAL	. .	113245 50.00	113246 50.00	226491 100.00

Table 35: Lap-Belt Only Any Injury Adjusted to Unrestrained Damage Type

INJURY RESTRAIN

FREQUENCY PERCENT COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	65218 28.79 57.59	56471 24.93 49.87	121689 53.73
YES	0 . .	48028 21.21 42.41	56775 25.07 50.13	104803 46.27
TOTAL	. .	113246 50.00	113246 50.00	226492 100.00

Table 36: Lap-and-Shoulder Averages
for the Data Adjusted to Unrestrained Damage Type

RESTRAIN	VEH_WT	VEH_MY	DELTAV	OCC_AGE
L&S	31.0196	75.9169	18.4489	33.2800
LAP	.	.	.	.
NONE	33.1935	72.9522	20.0068	30.7473

Table 37: Lap-Belt Only Averages
for the Data Adjusted to Unrestrained Damage Type

RESTRAIN	VEH_WT	VEH_MY	DELTAV	OCC_AGE
L&S	.	.	.	.
LAP	33.5601	71.2459	18.1376	35.4097
NONE	33.2003	72.9501	19.9779	30.7525

Table 38: Fatalities Adjusted to Lap-and-Shoulder Damage Type for Cases with Delta V Known

FATAL — RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	3355 49.78 99.55	0 . .	3352 49.72 99.45	6707 99.50
YES	15 0.22 0.45	0 . .	19 0.28 0.55	34 0.50
TOTAL	3371 50.00	. .	3370 50.00	6741 100.00

Table 39: Serious Injury Adjusted to Lap-and-Shoulder Damage Type for Cases with Delta V Known

SERIOUS — RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	3291 48.82 97.64	0 . .	3265 48.44 96.88	6556 97.26
YES	79 1.18 2.36	0 . .	105 1.56 3.12	185 2.74
TOTAL	3371 50.00	. .	3370 50.00	6741 100.00

Table 40: Moderate Injury Adjusted to Lap-and-Shoulder Damage Type for Cases with Delta V Known

MODERATE RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	3209 47.61 95.22	0 . .	3082 45.73 91.46	6292 93.34
YES	161 2.39 4.78	0 . .	288 4.27 8.54	449 6.66
TOTAL	3371 50.00	. .	3370 50.00	6741 100.00

Table 41: Any Injury Adjusted to Lap-and-Shoulder Damage Type for Cases with Delta V Known

INJURY RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	1995 29.60 59.20	0 . .	1709 25.36 50.72	3705 54.96
YES	1375 20.40 40.80	0 . .	1661 24.64 49.28	3036 45.04
TOTAL	3371 50.00	. .	3370 50.00	6741 100.00

Table 42: Fatalities Adjusted to Lap-Belt Only Damage Type for Cases with Delta V Known

FATAL / RESTRAIN

FREQUENCY PERCENT COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	2087 49.71 99.42	2085 49.67 99.35	4172 99.39
YES	0 . .	12 0.29 0.58	14 0.32 0.65	26 0.61
TOTAL	. .	2099 50.00	2099 50.00	4198 100.00

Table 43: Serious Injury Adjusted to Lap-Belt Only Damage Type for Cases with Delta V Known

SERIOUS / RESTRAIN

FREQUENCY PERCENT COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	2059 49.05 98.09	2030 48.35 96.71	4089 97.40
YES	0 . .	40 0.96 1.91	69 1.64 3.29	109 2.60
TOTAL	. .	2099 50.00	2099 50.00	4198 100.00

Table 44: Moderate Injury Adjusted to Lap-Belt Only Damage Type for Cases with Delta V Known

MODERATE RESTRAIN

FREQUENCY PERCENT COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	1996 47.55 95.10	1920 45.73 91.47	3916 93.29
YES	0 . .	103 2.45 4.90	179 4.26 8.53	282 6.71
TOTAL	. .	2099 50.00	2099 50.00	4198 100.00

Table 45: Any Injury Adjusted to Lap-Belt Only Damage Type for Cases with Delta V Known

INJURY RESTRAIN

FREQUENCY PERCENT COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	1237 29.46 58.92	1084 25.82 51.64	2321 55.28
YES	0 . .	862 20.54 41.08	1015 24.18 48.36	1877 44.72
TOTAL	. .	2099 50.00	2099 50.00	4198 100.00

Table 46: Fatalities Adjusted to Lap-and-Shoulder Damage Type for Cases with Delta V Unknown

FATAL   RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	4002 49.80 99.59	0 . .	3972 49.43 98.87	7974 99.23
YES	16 0.21 0.41	0 . .	46 0.57 1.13	62 0.77
TOTAL	4018 50.00	. .	4018 50.00	8036 100.00

Table 47: Serious Injury Adjusted to Lap-and-Shoulder Damage Type for Cases with Delta V Unknown

SERIOUS   RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	3951 49.17 98.34	0 . .	3868 48.14 96.28	7820 97.31
YES	67 0.83 1.66	0 . .	150 1.86 3.72	216 2.69
TOTAL	4018 50.00	. .	4018 50.00	8036 100.00

Table 48: Moderate Injury Adjusted to Lap-and-Shoulder Damage Type for Cases with Delta V Unknown

MODERATE FREQUENCY PERCENT COL PCT	RESTRAIN L&S	LAP	NONE	TOTAL
NO	3876 48.23 96.46	0 . .	3674 45.72 91.45	7550 93.96
YES	142 1.77 3.54	0 . .	344 4.28 8.55	486 6.04
TOTAL	4018 50.00	. .	4018 50.00	8036 100.00

Table 49: Any Injury Adjusted to Lap-and-Shoulder Damage Type for Cases with Delta V Unknown

INJURY FREQUENCY PERCENT COL PCT	RESTRAIN L&S	LAP	NONE	TOTAL
NO	2428 30.21 60.42	0 . .	2172 27.03 54.06	4600 57.24
YES	1590 19.79 39.58	0 . .	1846 22.97 45.94	3436 42.76
TOTAL	4018 50.00	. .	4018 50.00	8036 100.00

Table 50: Fatalities Adjusted to Lap-Belt Only Damage Type
for Cases with Delta V Unknown

FATAL RESTRAIN

FREQUENCY PERCENT COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	1747 49.72 99.43	1742 49.58 99.17	3489 99.30
YES	0 . .	10 0.28 0.57	15 0.41 0.83	25 0.70
TOTAL	. .	1757 50.00	1757 50.00	3514 100.00

Table 51: Serious Injury Adjusted to Lap-Belt Only Damage Type
for Cases with Delta V Unknown

SERIOUS RESTRAIN

FREQUENCY PERCENT COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	1713 48.75 97.51	1698 48.34 96.69	3411 97.10
YES	0 . .	44 1.25 2.49	58 1.66 3.31	102 2.90
TOTAL	. .	1757 50.00	1757 50.00	3514 100.00

Table 52: Moderate Injury Adjusted to Lap-Belt Only Damage Type for Cases with Delta V Unknown

MODERATE RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	1664 47.37 94.73	1616 45.99 91.98	3280 93.35
YES	0 . .	93 2.63 5.27	141 4.01 8.02	234 6.65
TOTAL	. .	1757 50.00	1757 50.00	3514 100.00

Table 53: Any Injury Adjusted to Lap-Belt Only Damage Type for Cases with Delta V Unknown

INJURY RESTRAIN

FREQUENCY / PERCENT / COL PCT	L&S	LAP	NONE	TOTAL
NO	0 . .	1113 31.69 63.38	955 27.19 54.38	2069 58.88
YES	0 . .	643 18.31 36.62	801 22.81 45.62	1445 41.12
TOTAL	. .	1757 50.00	1757 50.00	3514 100.00

Computer Program 1: Creation of the NCSS Data Subset

```
/*ROUTE XEQ MSS
/*UNNUMBERED
//PROCLIB DD DSN=ZABCRUN.PROCLIB,DISP=SHR
//STEP1 EXEC SAS,REGION=512K
//NCSSBEST DD DSN=WQP1DIB.NCSS.BEST.SAS.AUG0681.MAST,
//    DISP=SHR
//NCSSPOST DD DSN=WQR1DIB.NCSS.DB.POST.SAS.@16APR80.MAST,
//    DISP=SHR
//RESULTS DD DSN=WQR1SZP.CONTROL1.DEC0783,DISP=OLD,UNIT=MSS
//SYSIN DD *
DATA VEH0;
SET NCSSBEST.VEHICLE0 NCSSPOST.VEHICLE0;
BY TEAM;
KEEP CASENO VEHNO V_EXTENT V_AREA V_WEIGHT V_YEAR;
IF 1<=VBDYSTY<=4 AND VAPPVEH=1;
V_EXTENT=.;
IF 1<=VEXTEP<=9 THEN V_EXTENT=VEXTEP;
V_AREA='      ';
IF VGADPR='F' THEN V_AREA='FRONT';
IF VGADPR='L' OR VGADPR='R' THEN V_AREA='SIDE ';
IF VGADPR='B' THEN V_AREA='BACK ';
IF VGADPR='T' THEN V_AREA='TOP  ';
IF VGADPR='U' THEN V_AREA='UNDER';
V_WEIGHT=.;
IF 001<=VVEHWT<=100 THEN V_WEIGHT=VVEHWT;
V_YEAR=.;
IF 30<=VMDLYR<=90 THEN V_YEAR=VMDLYR;
DATA SEV;
SET NCSSBEST.SEVERITY NCSSPOST.SEVERITY;
BY TEAM;
KEEP CASENO VEHNO V_DELTAV;
V_DELTAV=.;
IF 00<=DVTDAM1<=99 THEN V_DELTAV=INT(DVTDAM1*8/5);
DATA OCC0;
SET NCSSBEST.OCCUPNT0 NCSSPOST.OCCUPNT0;
BY TEAM;
KEEP CASENO VEHNO OCCNO OCKHAM RESTRAIN AGE FATAL AIS1;
IF 10<=AGE<=98 AND SEATAREA=1;
OCKHAM=WEIGHTFA;
RESTRAIN='    ';
IF RESTRINV=0 OR RESTRINV=8 THEN RESTRAIN='NONE';
IF RESTRINV=1 THEN RESTRAIN='L&S ';
IF RESTRINV=2 THEN RESTRAIN='LAP ';
IF 3<=RESTRINV<=7 THEN RESTRAIN='MISC';
IF AGE=98 THEN AGE=97;
FATAL='NO ';
IF 1<=NCSSCLAS<=3 THEN FATAL='YES';
IF OVERALLA=0 THEN AIS1=0;
IF OVERALLA=8 OR AIS1=8 THEN AIS1=7;
IF AIS1=9 OR OVERALLA=9 THEN AIS1=.;
DATA RESULTS.NCSSDATA;
MERGE OCC0(IN=A) VEH0(IN=B) SEV;
BY CASENO VEHNO;
IF A=1 AND B=1;
```

Computer Program 2: Creation of the NCSS-NASS Data Subset

```
/*ROUTE XEQ 9T6250
/*MESSAGE 061934,R
/*ACCESS WQR1UXC
/*UNNUMBERED
//PROCLIB DD DSN=ZABCRUN.PROCLIB,DISP=SHR
//STEP1 EXEC SAS,REGION=512K
//NCSSNASS DD DSN=WQR1UXC.NANAL.NCSS.MASTER.SAS.@30JUL81,
//   UNIT=9T6250,VOL=SER=061934,DISP=OLD
//RESULTS DD DSN=WQR1SZP.CONTROL1.DEC0783,DISP=OLD,UNIT=MSS
//SYSIN DD *
DATA ACC;
SET NCSSNASS.ACCIDENT;
KEEP H01 H02 OCKHAM;
IF A10C=1 THEN OCKHAM=1;
IF A10C=2 THEN OCKHAM=4/3;
IF A10C=3 THEN OCKHAM=2;
IF A10C=4 THEN OCKHAM=5;
IF A10C=5 THEN OCKHAM=100/15;
IF A10C=6 THEN OCKHAM=20;
DATA VEHSEV;
SET NCSSNASS.VEHICLE;
KEEP PSU CASENO VEHNO V_EXTENT V_AREA V_WEIGHT V_YEAR V_DELTAV;
IF 1<=V13<=9 AND V09=2;
PSU=H01;
CASENO=H02;
VEHNO=H06;
V_EXTENT=.;
IF 1<=V21<=9 THEN V_EXTENT=V21;
V_AREA='     ';
IF V17='F' THEN V_AREA='FRONT';
IF V17='L' OR V17='R' THEN V_AREA='SIDE ';
IF V17='B' THEN V_AREA='BACK ';
IF V17='T' THEN V_AREA='TCP  ';
IF V17='U' THEN V_AREA='UNDER';
V_WEIGHT=.;
IF 001<=V43<=100 THEN V_WEIGHT=V43;
V_YEAR=.;
IF 30<=V10<=90 THEN V_YEAR=V10;
V_DELTAV=.;
IF 00<=V46<=99 THEN V_DELTAV=V46;
DATA OCC;
MERGE ACC NCSSNASS.OCCUPANT;
BY H01 H02;
KEEP PSU CASENO VEHNO OCCNO OCKHAM RESTRAIN AGE FATAL AIS1;
IF 10<=O08<=97 AND (1<=O13<=3 OR O13=10);
PSU=H01;
CASENO=H02;
VEHNO=H06;
OCCNO=O07;
RESTRAIN='    ';
IF O24=1 THEN RESTRAIN='NONE';
IF O24=2 THEN RESTRAIN='L&S ';
IF O24=3 THEN RESTRAIN='LAP ';
IF 4<=O24<=7 THEN RESTRAIN='MISC';
AGE=O08;
FATAL='NO ';
IF O19=1 THEN FATAL='YES';
AIS1=O32;
IF O32=8 OR O32=.A THEN AIS1=0;
IF O32=9 OR O32=.U THEN AIS1=.;
IF FATAL='YES' AND (O34<1 OR O34>3) THEN AIS1=7;
IF FAJAL='YES' AND (AIS1<1 OR AIS1>7) THEN AIS1=7;
DATA RESULTS.NCSSNASS;
MERGE OCC(IN=A) VEHSEV(IN=B);
BY PSU CASENO VEHNO;
IF A=1 AND B=1;
```

Computer Program 3: Creation of the 1979 NASS Data Subset

```
/*ROUTE XEQ MSS
/*UNNUMBERED
//PROCLIB DD DSN=ZABCRUN.PROCLIB,DISP=SHR
//STEP1 EXEC SAS,REGION=512K
//NASS79 DD DSN=WQR1DIB.NASS.ANALYSIS.MAST79.SAS.V4.FEB0481,
//    DISP=SHR
//RESULTS DD DSN=WQR1SZP.CONTROL1.DEC0783,DISP=OLD,UNIT=MSS
//SYSIN DD *
DATA VEHSEV;
SET NASS79.VEHICLE;
KEEP PSU CASENO VEHNO V_EXTENT V_AREA V_WEIGHT V_YEAR V_DELTAV;
IF 1<=V13<=9 AND V09=2;
PSU=H01;
CASENO=H02A;
VEHNO=H06;
V_EXTENT=.;
IF 1<=V21<=9 THEN V_EXTENT=V21;
V_AREA='     ';
IF V17='F' THEN V_AREA='FRONT';
IF V17='L' OR V17='R' THEN V_AREA='SIDE ';
IF V17='B' THEN V_AREA='BACK ';
IF V17='T' THEN V_AREA='TOP  ';
IF V17='U' THEN V_AREA='UNDER';
V_WEIGHT=.;
IF 001<=V43<=100 THEN V_WEIGHT=V43;
V_YEAR=.;
IF 30<=V10<=90 THEN V_YEAR=V10;
V_DELTAV=.;
IF 00<=V46<=99 THEN V_DELTAV=V46;
DATA OCC;
SET NASS79.OCCUPANT;
KEEP PSU CASENO VEHNO OCCNO OCKHAM RESTRAIN AGE FATAL AIS1 NATWGT;
IF 10<=O08<=97 AND (1<=O13<=3 OR O13=10);
PSU=H01;
CASENO=H02A;
VEHNO=H06;
OCCNO=O07;
IF H02B='A' OR H02B='D' OR H02B='G' OR H02B='H' OR
   H02B='K' OR H02B='L' THEN OCKHAM=1;
IF H02B='B' THEN OCKHAM=25/15;
IF H02B='C' OR H02B='M' THEN OCKHAM=5;
IF H02B='E' THEN OCKHAM=25/18;
IF H02B='F' THEN OCKHAM=25/12;
IF H02B='I' THEN OCKHAM=25/8;
IF H02B='J' THEN OCKHAM=25/2;
IF H02B='N' THEN OCKHAM=25;
RESTRAIN='    ';
IF O24=1 THEN RESTRAIN='NONE';
IF O24=2 THEN RESTRAIN='L&S ';
IF O24=3 THEN RESTRAIN='LAP ';
IF 4<=O24<=7 THEN RESTRAIN='MISC';
AGE=O08;
FATAL='NO ';
IF O19=1 THEN FATAL='YES';
AIS1=O32;
IF O32=8 OR O32=.A THEN AIS1=0;
IF O32=9 OR O32=.U THEN AIS1=.;
IF FATAL='YES' AND (O34<1 OR O34>3) THEN AIS1=7;
IF FATAL='YES' AND (AIS1<1 OR AIS1>7) THEN AIS1=7;
NATWGT=H08;
DATA RESULTS.NASS1979;
MERGE OCC(IN=A) VEHSEV(IN=B);
BY PSU CASENO VEHNO;
IF A=1 AND B=1;
```

Computer Program 4: Creation of the 1980 NASS Data Subset

```
/*ROUTE XEQ MSS
/*UNNUMBERED
//PROCLIB DD DSN=ZABCRUN.PROCLIB,DISP=SHR
//STEP1 EXEC SAS,REGION=512K
//NASS81 DD DSN=WQR1UYE.HJE.SAS81.FINALV,DISP=SHR
//RESULTS DD DSN=WQR1SZP.CONTROL1.DEC0783,DISP=OLD,UNIT=MSS
//SYSIN DD *
DATA VEHSEV;
SET NASS81.VEHICLE;
KEEP PSU CASENO VEHNO V_EXTENT V_AREA V_WEIGHT V_YEAR V_DELTAV;
IF 1<=BODY_TYP<=9 AND TOWAWAY=2;
CASENO=CASE_NO;
VEHNO=VEH_NO;
V_EXTENT=.;
IF 1<=EXTENTPR<=9 THEN V_EXTENT=EXTENTPR;
V_AREA='     ';
IF DEFLOCPR='F' THEN V_AREA='FRONT';
IF DEFLOCPR='L' OR DEFLOCPR='R' THEN V_AREA='SIDE ';
IF DEFLOCPR='B' THEN V_AREA='BACK ';
IF DEFLOCPR='T' THEN V_AREA='TOP  ';
IF DEFLOCPR='U' THEN V_AREA='UNDER';
V_WEIGHT=.;
IF 001<=CURB_WT<=100 THEN V_WEIGHT=CURB_WT;
V_YEAR=.;
IF 30<=MOD_YEAR<=90 THEN V_YEAR=MOD_YEAR;
V_DELTAV=.;
IF 00<=DV_TOTAL<=99 THEN V_DELTAV=DV_TOTAL;
DATA OCC;
SET NASS81.OCCUPANT;
KEEP PSU CASENO VEHNO OCCNO OCKHAM RESTRAIN AGE FATAL AIS1 NATWGT
     RATWGT;
IF 10<=OCC_AGE<=97 AND (1<=SEAT_POS<=3 OR SEAT_POS=10);
CASENO=CASE_NO;
VEHNO=VEH_NO;
OCCNO=OCC_NO;
IF STRATIF='A' OR STRATIF='D' OR STRATIF='G' OR STRATIF='H' OR
   STRATIF='K' OR STRATIF='L' THEN OCKHAM=1;
IF STRATIF='B' THEN OCKHAM=25/15;
IF STRATIF='C' OR STRATIF='M' THEN OCKHAM=5;
IF STRATIF='E' THEN OCKHAM=25/18;
IF STRATIF='F' THEN OCKHAM=25/12;
IF STRATIF='I' THEN OCKHAM=25/8;
IF STRATIF='J' THEN OCKHAM=25/2;
IF STRATIF='N' THEN OCKHAM=25;
RESTRAIN='    ';
IF MAN_REST=0 THEN RESTRAIN='NONE';
IF MAN_REST=3 THEN RESTRAIN='L&S ';
IF MAN_REST=2 THEN RESTRAIN='LAP ';
IF MAN_REST=1 OR 4<=MAN_REST<=8 THEN RESTRAIN='MISC';
AGE=OCC_AGE;
FATAL='NO ';
IF OTREATMT=1 THEN FATAL='YES';
AIS1=OAIS1;
IF OAIS1=8 OR OAIS1=.A THEN AIS1=0;
IF OAIS1=9 OR OAIS1=.U THEN AIS1=.;
IF FATAL='YES' AND (ODATSOU1<1 OR ODATSOU1>4) THEN AIS1=7;
IF FATAL='YES' AND (AIS1<1 OR AIS1>7) THEN AIS1=7;
NATWGT=NATWT;
RATWGT=RATEST;
DATA RESULTS.NASS1981;
MERGE OCC(IN=A) VEHSEV(IN=B);
BY PSU CASENO VEHNO;
IF A=1 AND B=1;
```

Computer Program 5: Creation of the 1981 NASS Data Subset

```
/*ROUTE XEQ MSS
/*UNNUMBERED
//PROCLIB DD DSN=ZABCRUN.PROCLIB,DISP=SHR
//STEP1 EXEC SAS,REGION=512K
//VEH80 DD DSN=WQR1BYE.NASS.ANALYSIS.MST80.VEHICLE,
//    DISP=SHR
//OCC80 DD DSN=WQR1BYE.NASS.ANALYSIS.MST80.OCCUPANT,
//    DISP=SHR
//RESULTS DD DSN=WQR1SZP.CONTROL1.DEC0783,DISP=OLD,UNIT=MSS
//SYSIN DD *
DATA VEHSEV;
SET VEH80.VEHICLE;
KEEP PSU CASENO VEHNO V_EXTENT V_AREA V_WEIGHT V_YEAR V_DELTAV;
IF 1<=V14<=9 AND V10=2;
PSU=H01;
CASENO=H02A;
VEHNO=H07;
V_EXTENT=.;
IF 1<=V24<=9 THEN V_EXTENT=V24;
V_AREA='      ';
IF V20='F' THEN V_AREA='FRONT';
IF V20='L' OR V20='R' THEN V_AREA='SIDE ';
IF V20='B' THEN V_AREA='BACK ';
IF V20='T' THEN V_AREA='TOP  ';
IF V20='U' THEN V_AREA='UNDER';
V_WEIGHT=.;
IF 001<=V46<=100 THEN V_WEIGHT=V46;
V_YEAR=.;
IF 30<=V11<=90 THEN V_YEAR=V11;
V_DELTAV=.;
IF 00<=V50<=99 THEN V_DELTAV=V50;
DATA OCC;
SET OCC80.OCCUPANT;
KEEP PSU CASENO VEHNO OCCNO OCKHAM RESTRAIN AGE FATAL AIS1 NATWGT;
IF 10<=O09<=97 AND (1<=O14<=3 OR O14=10);
PSU=H01;
CASENO=H02A;
VEHNO=H07;
OCCNO=O08;
IF H02B='A' OR H02B='D' OR H02B='G' OR H02B='H' OR
   H02B='K' OR H02B='L' THEN OCKHAM=1;
IF H02B='B' THEN OCKHAM=25/15;
IF H02B='C' OR H02B='M' THEN OCKHAM=5;
IF H02B='E' THEN OCKHAM=25/18;
IF H02B='F' THEN OCKHAM=25/12;
IF H02B='I' THEN OCKHAM=25/8;
IF H02B='J' THEN OCKHAM=25/2;
IF H02B='N' THEN OCKHAM=25;
RESTRAIN='    ';
IF O24=0 THEN RESTRAIN='NONE';
IF O24=3 THEN RESTRAIN='L&S ';
IF O24=2 THEN RESTRAIN='LAP ';
IF O24=1 OR 4<=O24<=8 THEN RESTRAIN='MISC';
AGE=O09;
FATAL='NO ';
IF O20=1 THEN FATAL='YES';
AIS1=O32;
IF O32=8 OR O32=.A THEN AIS1=0;
IF O32=9 OR O32=.U THEN AIS1=.;
IF FATAL='YES' AND (O34<1 OR O34>3) THEN AIS1=7;
IF FATAL='YES' AND (AIS1<1 OR AIS1>7) THEN AIS1=7;
NATWGT=H09;
DATA RESULTS.NASS1980;
MERGE OCC(IN=A) VEHSEV(IN=B);
BY PSU CASENO VEHNO;
IF A=1 AND B=1;
```

Computer Program 6: Creation of the 1982 NASS Data Subset

```
/*ROUTE XEQ MSS
/*ROUTE XEQ 9T6250
/*MESSAGE 061489,R
/*ACCESS WQR1UYW
/*UNNUMBERED
//PROCLIB DD DSN=ZABCRUN.PROCLIB,DISP=SHR
//STEP1 EXEC SAS,REGION=512K
//NASS82 DD DSN=WQR1UYW.NANAL.CSS82.SAS.V1.OCT1783,
//   UNIT=9T6250,VOL=SER=061489,DISP=OLD
//RESULTS DD DSN=WQR1SZP.CONTROL1.DEC0783,DISP=OLD,UNIT=MSS
//SYSIN DD *
DATA VEHSEV;
SET NASS82.VEHICLE;
KEEP PSU CASENO VEHNO V_EXTENT V_AREA V_WEIGHT V_YEAR V_DELTAV;
IF 1<=BODYTYPE<=9 AND TOWAWAY=2;
V_EXTENT=.;
IF 1<=EXTENT1<=9 THEN V_EXTENT=EXTENT1;
V_AREA='      ';
IF GAD1='F' THEN V_AREA='FRONT';
IF GAD1='L' OR GAD1='R' THEN V_AREA='SIDE ';
IF GAD1='B' THEN V_AREA='BACK ';
IF GAD1='T' THEN V_AREA='TOP  ';
IF GAD1='U' THEN V_AREA='UNDER';
V_WEIGHT=.;
IF 001<=CURBWGT<=100 THEN V_WEIGHT=CURBWGT;
V_YEAR=.;
IF 30<=MODELYR<=90 THEN V_YEAR=MODELYR;
V_DELTAV=.;
IF 00<=DVTOTAL<=99 THEN V_DELTAV=DVTOTAL;
DATA OCC;
SET NASS82.OCCUPANT;
KEEP PSU CASENO VEHNO OCCNO OCKHAM RESTRAIN AGE FATAL AIS1 NATWGT;
IF 10<=AGE<=97 AND (1<=SEATPOS<=3 OR SEATPOS=10);
IF STRATIF='A' OR STRATIF='B' OR STRATIF='E' OR STRATIF='F' OR
   STRATIF='J' OR STRATIF='K' OR STRATIF='L' OR STRATIF='N' OR
   STRATIF='N' THEN OCKHAM=1;
IF STRATIF='M' OR STRATIF='S' OR STRATIF='T'
   THEN OCKHAM=8/7;
IF STRATIF='G' THEN OCKHAM=4/3;
IF STRATIF='D' OR STRATIF='H' THEN OCKHAM=8/5;
IF STRATIF='Q' OR STRATIF='V' THEN OCKHAM=2;
IF STRATIF='C' THEN OCKHAM=8/3;
IF STRATIF='R' OR STRATIF='W' THEN OCKHAM=4;
IF OCKHAM-=.;
RESTRAIN='    ';
IF MANUSE=0 THEN RESTRAIN='NONE';
IF MANUSE=3 THEN RESTRAIN='L&S ';
IF MANUSE=2 THEN RESTRAIN='LAP ';
IF MANUSE=1 OR 4<=MANUSE<=8 THEN RESTRAIN='MISC';
FATAL='NO ';
IF TREATMNT=1 THEN FATAL='YES';
IF AIS1=8 OR AIS1=.A THEN AIS1=0;
IF AIS1=9 OR AIS1=.U THEN AIS1=.;
IF FATAL='YES' AND (SOUDAT1<1 OR SOUDAT1>4) THEN AIS1=7;
IF FATAL='YES' AND (AIS1<1 OR AIS1>7) THEN AIS1=7;
DATA RESULTS.NASS1982;
MERGE OCC(IN=A) VEHSEV(IN=B);
BY PSU CASENO VEHNO;
IF A=1 AND B=1;
```

Computer Program 7: Creation of the 1983 NASS Data Subset

```
/*ROUTE XEQ MSS
/*ROUTE XEQ 9T6250
/*MESSAGE 054438,R
/*ACCESS WQR1UYW
/*UNNUMBERED
//PROCLIB DD DSN=ZABCRUN.PROCLIB,DISP=SHR
//STEP1 EXEC SAS,REGION=512K
//NASS83 DD DSN=WQR1UYW.NAQC.CSS83.APP.SAS.SEQ01.AUG2683,
//    UNIT=9T6250,VOL=SER=054438,DISP=OLD
//RESULTS DD DSN=WQR1SZP.CONTROL1.DEC0783,DISP=OLD,UNIT=MSS
//SYSIN DD *
DATA VEHSEV;
SET NASS83.VEHICLE;
KEEP PSU CASENO VEHNO V_EXTENT V_AREA V_WEIGHT V_YEAR V_DELTAV;
IF 1<=V14<=9 AND V10=2;
PSU=H01;
CASENO=H02A;
VEHNO=H07;
V_EXTENT=.;
IF 1<=V32<=9 THEN V_EXTENT=V32;
V_AREA='     ';
IF V28='F' THEN V_AREA='FRONT';
IF V28='L' OR V28='R' THEN V_AREA='SIDE ';
IF V28='B' THEN V_AREA='BACK ';
IF V28='T' THEN V_AREA='TOP  ';
IF V28='U' THEN V_AREA='UNDER';
V_WEIGHT=.;
IF 001<=V75<=100 THEN V_WEIGHT=V75;
V_YEAR=.;
IF 30<=V11<=90 THEN V_YEAR=V11;
V_DELTAV=.;
IF 00<=V79<=99 THEN V_DELTAV=V79;
DATA OCC;
SET NASS83.OCCUPANT;
KEEP PSU CASENO VEHNO OCCNO OCKHAM RESTRAIN AGE FATAL AIS1;
IF 10<=O09<=97 AND (1<=O14<=3 OR O14=10);
PSU=H01;
CASENO=H02A;
VEHNO=H07;
OCCNO=O08;
IF H02B='A' OR H02B='B' OR H02B='E' OR H02B='F' OR
   H02B='J' OR H02B='K' OR H02B='L' OR H02B='N' OR
   H02B='N' THEN OCKHAM=1;
IF H02B='M' OR H02B='S' OR H02B='T'
   THEN OCKHAM=8/7;
IF H02B='G' THEN OCKHAM=4/3;
IF H02B='D' OR H02B='H' THEN OCKHAM=8/5;
IF H02B='Q' OR H02B='V' THEN OCKHAM=2;
IF H02B='C' THEN OCKHAM=8/3;
IF H02B='R' OR H02B='W' THEN OCKHAM=4;
IF OCKHAM¬=.;
RESTRAIN='    ';
IF O24=0 THEN RESTRAIN='NONE';
IF O24=3 THEN RESTRAIN='L&S ';
IF O24=2 THEN RESTRAIN='LAP ';
IF O24=1 OR 4<=O24<=8 THEN RESTRAIN='MISC';
AGE=O09;
FATAL='NO ';
IF O20=1 THEN FATAL='YES';
AIS1=O32;
IF AIS1=8 OR AIS1=.A THEN AIS1=0;
IF AIS1=9 OR AIS1=.U THEN AIS1=.;
IF FATAL='YES' AND (O34<1 OR O34>6) THEN AIS1=7;
IF FATAL='YES' AND (AIS1<1 OR AIS1>7) THEN AIS1=7;
DATA RESULTS.NASS1983;
MERGE OCC(IN=A) VEHSEV(IN=B);
BY PSU CASENO VEHNO;
IF A=1 AND B=1;
```

Computer Program 8: Tabulation, Adjustment, and **Comparison**
(Used to Produce Tables 1 through 17)

```
/*ROUTE XEQ MSS
/*UNNUMBERED
//PROCLIB DD DSN=ZABCRUN.PROCLIB,DISP=SHR
//STEP1 EXEC SAS,REGION=512K
//RESULTS DD DSN=WQR1SZP.CONTROL1.DEC0783,DISP=SHR
//SYSIN DD *
OPTIONS LS=78;
DATA COLLECT;
SET RESULTS.NCSSDATA(IN=A) RESULTS.NCSSNASS(IN=B)
     RESULTS.NASS1979(IN=C) RESULTS.NASS1980(IN=D)
     RESULTS.NASS1981(IN=E) RESULTS.NASS1982(IN=F)
     RESULTS.NASS1983(IN=G);
IF A=0 AND B=0 AND CASENO>500 THEN DELETE;
IF RESTRAIN='MISC' OR RESTRAIN='    ' THEN DELETE;
IF V_AREA='      ' THEN DELETE;
IF V_EXTENT=. THEN DELETE;
IF A THEN DO;
   IF V_DELTAV>=96 THEN V_DELTAV=95;
END;
IF B OR C THEN DO;
   IF 96<=V_DELTAV<=200 THEN V_DELTAV=95;
   IF V_DELTAV>200 THEN V_DELTAV=.;
END;
IF D OR E THEN DO;
   IF V_DELTAV>95 THEN V_DELTAV=.;
END;
IF F OR G THEN DO;
   IF 96<=V_DELTAV<=97 THEN V_DELTAV=95;
   IF V_DELTAV>97 THEN V_DELTAV=.;
END;
IF V_DELTAV=95 THEN V_DELTAV=.H;
IF 3<=AIS1<=6 OR FATAL='YES' THEN SERIOUS='YES';
ELSE SERIOUS='NO ';
IF 2<=AIS1<=6 OR FATAL='YES' THEN MODERATE='YES';
ELSE MODERATE='NO ';
IF 1<=AIS1<=7 OR FATAL='YES' THEN INJURY='YES';
ELSE INJURY='NO ';
OCKHAM00=100*OCKHAM;
TITLE1 COMBINED NCSA DATA FOR AN EVALUATION OF RESTRAINTS;
TITLE2 WITH AN ATTEMPT TO CONTROL FOR CRASH CONDITIONS;
PROC FREQ DATA=COLLECT;
WEIGHT OCKHAM;
TABLES (FATAL SERIOUS MODERATE INJURY)*RESTRAIN
       RESTRAIN*V_EXTENT*V_AREA/NOROW OUT=CASES;
DATA NONE(RENAME=(COUNT=NONE))
     LAP(RENAME=(COUNT=LAP))
     L_S(RENAME=(COUNT=L_S));
SET CASES;
KEEP V_EXTENT V_AREA COUNT;
IF RESTRAIN='NONE' THEN OUTPUT NONE;
IF RESTRAIN='LAP ' THEN OUTPUT LAP;
IF RESTRAIN='L&S ' THEN OUTPUT L_S;
DATA ADDCOUNT;
MERGE NONE LAP L_S;
BY V_EXTENT V_AREA;
IF NONE=. THEN NONE=0;
IF LAP=. THEN LAP=0;
IF L_S=. THEN L_S=0;
PROC SORT DATA=COLLECT;
BY V_EXTENT V_AREA;
```

Computer Program 8: Tabulation, Adjustment, and Comparison
(continued)

```
DATA ADDED;
MERGE COLLECT ADDCOUNT;
BY V_EXTENT V_AREA;
IF L_S>NONE AND RESTRAIN='L&S ' THEN ADJ_L_S=NONE/L_S;
IF NONE>L_S AND RESTRAIN='NONE' THEN ADJ_L_S=L_S/NONE;
IF L_S=NONE OR
   (L_S>NONE AND RESTRAIN='NONE') OR
   (NONE>L_S AND RESTRAIN='L&S ') THEN ADJ_L_S=1;
IF L_S=0 OR NONE=0 THEN ADJ_L_S=0;
L_S_WT=ADJ_L_S*OCKHAM;
IF LAP>NONE AND RESTRAIN='LAP ' THEN ADJ_LAP=NONE/LAP;
IF NONE>LAP AND RESTRAIN='NONE' THEN ADJ_LAP=LAP/NONE;
IF LAP=NONE OR
   (LAP>NONE AND RESTRAIN='NONE') OR
   (NONE>LAP AND RESTRAIN='LAP ') THEN ADJ_LAP=1;
IF LAP=0 OR NONE=0 THEN ADJ_LAP=0;
LAP_WT=ADJ_LAP*OCKHAM;
L_S_WT00=100*L_S_WT;
LAP_WT00=100*LAP_WT;
PROC SORT DATA=ADDED;
BY RESTRAIN;
PROC MEANS DATA=ADDED NOPRINT;
BY RESTRAIN;
FREQ OCKHAM00;
VAR V_WEIGHT V_YEAR V_DELTAV AGE;
OUTPUT OUT=ORIGINAL MEAN=VEH_WT VEH_MY DELTAV OCC_AGE;
PROC PRINT DATA=ORIGINAL;
PROC FREQ DATA=ADDED;
WEIGHT L_S_WT;
TABLES (FATAL SERIOUS MODERATE INJURY)*RESTRAIN
       RESTRAIN*V_EXTENT*V_AREA/NOROW;
TITLE3 ADJUSTED FOR UNRESTRAINED VERSUS LAP-SHOULDER BELTS;
PROC MEANS DATA=ADDED NOPRINT;
BY RESTRAIN;
FREQ L_S_WT00;
VAR V_WEIGHT V_YEAR V_DELTAV AGE;
OUTPUT OUT=L_S_NONE MEAN=VEH_WT VEH_MY DELTAV OCC_AGE;
PROC PRINT DATA=L_S_NONE;
PROC FREQ DATA=ADDED;
WEIGHT LAP_WT;
TABLES (FATAL SERIOUS MODERATE INJURY)*RESTRAIN
       RESTRAIN*V_EXTENT*V_AREA/NOROW;
TITLE3 ADJUSTED FOR UNRESTRAINED VERSUS LAP-ONLY BELTS;
PROC MEANS DATA=ADDED NOPRINT;
BY RESTRAIN;
FREQ LAP_WT00;
VAR V_WEIGHT V_YEAR V_DELTAV AGE;
OUTPUT OUT=LAP_NONE MEAN=VEH_WT VEH_MY DELTAV OCC_AGE;
PROC PRINT DATA=LAP_NONE;
```

Note on Rear Seat Belt Use and Usefulness
Estimated from Automated Accident Data
March 1986

Note on Rear Seat Belt Use and Usefulness Estimated from Automated Accident Data

S. Partyka
March 1986

Because of the relative infrequency of both rear seat occupancy and seat belt use in the accident data, it was necessary to combine all available data sources to address the question of rear seat belt usefulness in preventing injuries and death. The following eight sources were combined for this purpose:

NCSS data -- the National Crash Severity Study data collected between January 1977 and March 1979;
NCSS-NASS -- data collected on the National Accident Sampling System forms by the former-NCSS teams between April 1979 and March 1980; and
NASS data -- data collected for each of the years 1979 through 1984 by the National Accident Sampling System.

The people selected from these sources were

Rear seat occupants
of a passenger car
that was towed for damage received in the accident
and who were at least 5 years old.

In order to make estimates from these data, it is necessary to compensate for the differential sampling scheme -- serious accidents were selected with a higher probability in order to ensure their inclusion in the data files. For NCSS and NCSS-NASS, the inverse of the probability of accident selection was used; these weighting factors are simple and take on only a few different values. For NASS the situation is more complicated -- the NASS weighting factors attempt to produce national estimates and vary wildly. So instead, a simplified weighting scheme which has been used previously (called Ockham weights) was used. The basis of Ockham weights is the assumption that a fatality is a fatality, and is weighted by 1. All other cases are weighted according to their average relative sampling probability.

There were a total of 7,578 people who met the requirements of this Note. Of these, 129 were killed and 952 were hospitalized overnight.

Medical Treatment Received in the Unweighted Sample Data

Treatment	NCSS Data	NCSS-NASS	1979 NASS	1980 NASS	1981 NASS	1982 NASS	1983 NASS	1984 NASS	Total
Fatality	58	26	5	4	9	5	8	14	129
Hospital	472	112	39	21	57	72	70	109	952
Other	1129	260	83	58	147	262	286	393	2618
None	1107	255	168	139	312	413	509	627	3530
Unknown	124	37	10	10	25	45	26	72	349
Total	2890	690	305	232	550	797	899	1215	7578

Another way of describing the injury consequences is in terms of the Abbreviated Injury Scale (AIS). In the summary below, all fatalities are categorized together rather than by AIS. There were 494 seriously injured people in the sample -- those with an AIS 3 or greater (including all fatalities).

Injury Severity in the Unweighted Sample Data

Maximum AIS	NCSS Data	NCSS-NASS	1979 NASS	1980 NASS	1981 NASS	1982 NASS	1983 NASS	1984 NASS	Total
0 (none)	1022	229	128	130	259	327	441	552	3088
1 (minor)	669	258	118	68	178	321	331	438	2381
2 (moderate)	203	72	27	12	40	55	46	79	534
3 (serious)	126	39	8	6	28	16	23	30	276
4 (severe)	34	12	4	1	3	2	5	7	68
5 (critical)	10	3	0	1	1	2	1	3	21
Inj Sev Unk	463	40	15	10	29	69	42	91	759
Unk if Inj	305	11	0	0	3	0	2	1	322
Fatality	58	26	5	4	9	5	8	14	129
Total	2890	690	305	232	550	797	899	1215	7578

Only 272 of these people were reported to have been in a lap belt, 5 in a lap-and-shoulder belt system, 4 in a child seat, and 4 in some other restraint.

Restraint Use in the Unweighted Sample Data

Restraint	NCSS Data	NCSS-NASS	1979 NASS	1980 NASS	1981 NASS	1982 NASS	1983 NASS	1984 NASS	Total
None	2687	653	290	229	522	724	827	1031	6963
Lap Only	26	9	8	3	8	50	45	123	272
Lap and Shoulder	0	0	0	0	0	0	2	3	5
Child Seat	0	0	0	0	0	0	3	1	4
Other Type	0	0	0	0	2	0	2	0	4
Unknown	177	28	7	0	18	23	20	57	330
Total	2890	690	305	232	550	797	899	1215	7578

A substantial portion of the more serious injury consequences were sampled in NCSS and NCSS-NASS; but the bulk of the reported belt use cases were sampled in NASS. The intersection of these two sets of cases (serious injuries to lap-belted people) is therefore small. Only 16 people were killed or hospitalized after a sampled accident in which they were wearing a lap belt.

Restraint Use and Medical Treatment in the Unweighted Sample Data

Treatment	None	Lap Only	Lap and Shoulder	Child Seat	Other Type	Unknown	Total
Fatality	123	3	0	0	0	3	129
Hospital	921	13	0	0	0	18	952
Other	2442	77	2	3	0	94	2618
None	3207	165	2	1	2	153	3530
Unknown	270	14	1	0	2	62	349
Total	6963	272	5	4	4	330	7578

Only 5 of the people sampled were seriously injured or killed in an accident in which they were wearing a lap belt.

Restraint Use and Injury Severity in the Unweighted Sample Data

Maximum AIS	None	Lap Only	Lap and Shoulder	Child Seat	Other Type	Unknown	Total
0 (none)	2790	147	2	2	2	145	3088
1 (minor)	2219	85	2	2	0	73	2381
2 (moderate)	517	9	0	0	0	8	534
3 (serious)	266	2	0	0	0	8	276
4 (severe)	68	0	0	0	0	0	68
5 (critical)	19	0	0	0	0	2	21
Inj Sev Unk	688	23	1	0	2	45	759
Unk if Inj	273	3	0	0	0	46	322
Fatality	123	3	0	0	0	3	129
Total	6963	272	5	4	4	330	7578

The sample sizes preclude rigorous analysis. The weighted data produce only rough estimates of relative injury outcome and are not sufficient for statistical controls of crash severity and victim age. The fatality rates are

0.57 percent of the unrestrained and
0.35 percent for those wearing lap belts,
for an estimated effectiveness of 39 percent.

The rates of overnight hospitalization or fatality are

5.72 percent of the unrestrained and
2.44 percent for those wearing lap belts,
for an estimated effectiveness of 57 percent.

Estimates of Restraint Use and Medical Treatment in the Sample Areas

Treatment	None	Lap Only	Lap and Shoulder	Child Seat	Other Type	Unknown	Total
Fatality	128 0.57%	4 0.35%	0 0.00%	0 0.00%	0 0.00%	3 0.21%	134
Hospital	1154 5.15%	23 2.09%	0 0.00%	0 0.00%	0 0.00%	27 1.89%	1204
Other	5944 26.54%	187 17.03%	4 21.92%	9 69.23%	0 0.00%	284 19.77%	6427
None	14428 64.43%	824 75.16%	12 65.75%	4 30.77%	6 75.00%	877 61.07%	16151
Unknown	739 3.30%	59 5.37%	2 12.33%	0 0.00%	2 25.00%	245 17.07%	1048
Total	22393 100.00%	1096 100.00%	18 100.00%	13 100.00%	8 100.00%	1436 100.00%	24964

The estimates of injury severity are even more imprecise: there were no lap-belted people with AIS 4 or 5 injuries (but there were 4 fatalities). The proportions known to be injured were

38.66 percent for the unrestrained and
29.89 percent for those wearing lap belts,
for an estimated effectiveness of 23 percent.

Estimates of Restraint Use and Injury Severity in the Sample Areas

Maximum AIS	None	Lap Only	Lap and Shoulder	Child Seat	Other Type	Unknown	Total
0 (none)	12722 56.81%	740 67.55%	12 65.75%	6 46.15%	6 75.00%	783 54.56%	14270
1 (minor)	5471 24.43%	255 23.27%	4 21.92%	7 53.85%	0 0.00%	251 17.51%	5989
2 (moderate)	856 3.82%	14 1.24%	0 0.00%	0 0.00%	0 0.00%	14 0.97%	883
3 (serious)	360 1.61%	2 0.20%	0 0.00%	0 0.00%	0 0.00%	17 1.18%	379
4 (severe)	80 0.36%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	80
5 (critical)	22 0.10%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	2 0.14%	24
Inj Sev Unk	1740 7.77%	53 4.84%	2 12.33%	0 0.00%	2 25.00%	153 10.66%	1950
Unk if Inj	1015 4.53%	28 2.56%	0 0.00%	0 0.00%	0 0.00%	212 14.77%	1256
Fatality	128 0.57%	4 0.35%	0 0.00%	0 0.00%	0 0.00%	3 0.21%	134
Total	22393 100.00%	1096 100.00%	18 100.00%	13 100.00%	8 100.00%	1436 100.00%	24964

Note on the Bias Introduced by an Injury Threshold
on Estimates Made for Crashworthiness Research
April 1986

Note on the Bias Introduced by an Injury Threshold on Estimates Made for Crashworthiness Research

S. Partyka
April 1986

Using an injury threshold as a criterion for inclusion in an accident data file produces an irrecoverable bias that precludes crashworthiness analysis. To investigate the advantages of various vehicle designs, we need a data system that is defined solely in terms of a damage threshold. Some results from the National Crash Severity Study (NCSS, which was defined solely in terms of a towaway criterion) will demonstrate the difficulties of restricting data collection to even a low injury threshold.

There were 25,237 occupants of towed passenger cars collected under NCSS. The primary damage areas of their vehicles were as follows:

Table 1: Towaway Passenger Car Occupants on NCSS, Raw and Weighted

Damage Area	Raw Count	Weighted Estimate	Average Weight
Front	12,644	51,523	4.1
Side	5,864	23,820	4.1
Rollover	1,098	3,325	3.0
Other	1,413	6,315	4.5
Unknown	4,218	21,785	5.2
Total	25,237	106,768	4.2

The weighted data have been adjusted for the disproportinate sampling of higher injury severity cases. The weights are small: either 1, 4, 10, or 20. The weighted data will be used in the remainder of this Note. This represents our estimates of the accidents that occurred in the NCSS areas over the 27 months of the study.

Some definitions will help simplify the following presentation. We can define a "high injury vehicle" as one in which at least one occupant suffered a fatal or incapacitating injury (police code K or A) and at least one occupant (not necessarily the same one) was transported to a hospital from the accident scene or was killed. Other vehicles we can call "low injury vehicles", whatever the actual injury outcome was in terms of the Abbrevitated Injury Scale (AIS).

We can define a "high damage vehicle" as one that rolled over, had frontal damage with an extent zone of at least three (in terms of the Collision Deformation Classification -- CDC), or had side damage with an extent zone of at least four. Other vehicles with front or side damage we can call "low damage vehicles".

The following table shows the proportion of high and low injury vehicles by damage area and extent zone. The proportion of low injury vehicles is the proportion of vehicles which would be missed by beginning with this injury threshold for case selection. There is no extent zone threshold high enough that the injury criterion does not result in major data losses, and so biases, for crashworthiness research.

Table 2: Proportion of High Injury Vehicles, by Damage Type

Damage Area, Extent	Low Injury Vehicle Number	Low Injury Vehicle Percent	High Injury Vehicle Number	High Injury Vehicle Percent	Total Occupants
Front,					
Extent 1	19,589	96 %	805	4 %	20,394
Extent 2	18,299	89 %	2,297	11 %	20,596
Extent 3	4,222	71 %	1,687	29 %	5,909
Extent 4	945	61 %	600	39 %	1,545
Extent 5	592	65 %	312	35 %	904
Extent 6	626	79 %	170	21 %	796
Extent 7	182	50 %	184	50 %	366
Extent 8	126	64 %	72	36 %	198
Extent 9	593	73 %	222	27 %	815
Total	45,174	88 %	6,349	12 %	51,523
Side,					
Extent 1	2,514	99 %	38	1 %	2,552
Extent 2	8,240	97 %	273	3 %	8,513
Extent 3	9,458	87 %	1,421	13 %	10,879
Extent 4	854	59 %	584	41 %	1,438
Extent 5	106	37 %	177	63 %	283
Extent 6	15	22 %	53	78 %	68
Extent 7	2	6 %	32	94 %	34
Extent 8	0	0 %	7	100 %	7
Extent 9	20	43 %	26	57 %	46
Total	21,209	89 %	2,611	11 %	23,820
Rollover	2,548	77 %	777	23 %	3,325
Totals:					
Low Damage	58,100	92 %	4,834	8 %	62,934
High Damage	10,831	69 %	4,903	31 %	15,734
Overall	68,931	88 %	9,737	12 %	78,668

By beginning with high injury vehicles, we increase the proportion of high damage vehicles, from 20 percent (15,734 out of 78,668) to 50 percent (4,903 out of 9,737). This is because while overall only 12 percent (9,737 out of 78,668) frontal, side, and rollover vehicles have a high injury, 31 percent (4,903 out of 15,734) high damage vehicles also have a high injury. But by restricting case selection to vehicles with a high injury, we lose 69 percent of the high damage vehicles. This leaves us with no physically meaningful basis for computing injury rates. We can compute "serious injuries per high injury vehicle", but just what does that mean? It means something similar to "fatalities per fatal accident", a restriction that has plagued crashworthiness analysis of the Fatal Accident Reporting System (FARS) data. The FARS data are good for counts, but not for rates.

The following tables show the effects of the injury threshold on the computation of injury rates by restraint use, and so on the estimate of restraint effectiveness.

Table 3: Restraint Use and AIS in High Damage Vehicles

Restraint	AIS 0-2	AIS 3-6	Unknown	Total
No	10,946	1,778	1,517	14,241
Yes	636	69	44	749
Unknown	613	94	37	744
Total	12,195	1,941	1,598	15,734

Table 4: Restraint Use and AIS in High Damage, High Injury Vehicles

Restraint	AIS 0-2	AIS 3-6	Unknown	Total
No	2,260	1,540	774	4,574
Yes	42	56	27	125
Unknown	97	90	17	204
Total	2,399	1,686	818	4,903

For the high damage vehicles (regardless of the overall injury level of the vehicle), the serious injury rates (rates of AIS 3 or greater, computed from the known data only) are as follows:

Unrestrained rate = 1,778/12,724 = 13.97 percent
Restrained rate = 69/705 = 9.79 percent
Effectiveness = 30 percent.

For the high damage vehicles with high injury in the vehicle (defined in terms of police injury code and transport to a medical facility) the serious injury rates are as follows:

Unrestrained rate = 1,540/3,800 = 40.53 percent
Restrained rate = 56/98 = 57.14 percent
Effectiveness = -41 percent.

Using only high damage vehicles results in an estimated serious injury-reducing effectiveness of 30 percent for all types of seat belts combined. This is lower than the 40-50 percent effectiveness estimated by the National Highway Traffic Safety Administration for lap-and-shoulder belt systems in all types of crashes for two reasons. First, the 30 percent figure is based on all types of restraint systems, lap-only as well as lap-and-shoulder. We know that lap belts alone are less effective than when paired with a shoulder belt. Second, belts are less effective at higher crash speeds. So this estimate of 30 percent seems reasonable. On the other hand, the negative effectiveness (-41 percent) for high damage vehicles conditional on a high injury in the vehicles is a result of the bias built into the data by the injury threshold. It is hard to imagine a use for a crashworthiness data collection system which could not produce reasonable estimates of restraint use effectiveness.

Could a high injury threshold be used for acquiring serious injuries (those with an AIS of 3 or greater) for purely descriptive purposes? While only 5 percent (5,602 out of 106,768) of front, side, or rollover damaged vehicles have an occupant with an AIS 3 or greater, 35 percent (4,087 out of 11,514) of the high injury vehicles have an AIS 3 or greater. This is a substantial improvement in the acquisition rate for AIS 3 or greater injuries, but results in a loss of 27 percent (1,515 out of 5,602) of the AIS 3 or greater injuries in these damage areas. It is likely that the serious injuries that are missed differ from those that the police note as incapacitating. Those that are missed may be less-visible internal injuries or head injuries. So the high injury threshold has two problems: it cannot be used to produce serious injury rates, and it cannot be used to simply find and investigate representative serious injuries for descriptive purposes.

Table 5: Highest Police versus AIS Injury Coding in Vehicle

Highest AIS in Vehicle	Low Injury Vehicle		High Injury Vehicle		Total Occupants	
	Number	Percent	Number	Percent	Number	Percent
Less than 3	93,739	98 %	7,427	65 %	101,166	95 %
At least 3	1,515	2 %	4,087	35 %	5,602	5 %
Total	95,254	100 %	11,514	100 %	106,768	100 %

Note on Belt Effectiveness Estimates from Fatal Accidents

-- Comparison by Mandatory Belt Use Law Coverage

July 1986

Note on Belt Effectiveness Estimates from Fatal Accidents -- Comparison by Mandatory Belt Use Law Coverage

S. Partyka
July 1986

Front seat occupant restraints are estimated to be 56 percent effective in preventing fatalities, based upon data from the 1985 Fatal Accident Reporting System. The estimated effectiveness is slightly higher for people covered by mandatory belt use laws (59 percent effective) than for those not covered (54 percent effective). This difference may reflect the variability of the data, it may result from reporting biases associated with the law, or it may instead indicate increased effectiveness for higher levels of belt use.

The driver seat belt appears to be more effective (58 percent effective) than the belt in the right-front passenger seat (50 percent effective) in preventing fatalities. This may be the result of differences in the vehicle interior for these seating positions, differences in the people by seating position, or reporting biases.

Data

There were 20,405 outboard front seat car occupant fatalities five years and older in 1985. Of these, 15,510 were drivers and 4,895 were right front passengers. Restraint use is unknown on the Fatal Accident Reporting System for 18 percent of these people. The unknown data are excluded from most of this analysis.

There were eight states with mandatory belt use laws in 1985. For simplicity, the periods covered by a belt law are rounded to the nearest month. The covered states and months are shown in the next table.

Mandatory Belt Use Laws in Effect in 1985

State	Effective Date	Months Covered in 1985
New York	December 1, 1984	January - December
New Jersey	March 1, 1985	March - December
Illinois	July 1, 1985	July - December
Michigan	July 1, 1985	July - December
Texas	September 1, 1985	September - December
Nebraska	September 6, 1985	September - December
Missouri	September 28, 1985	October - December
North Carolina	October 1, 1985	October - December

The numbers of car occupant fatalities five years and older are shown below for months and states covered (or not covered) by a mandatory belt use law.

Fatalities by Belt Use Law Coverage

Seating Position	Overall	No Law	With Law
Driver	15,510	13,286	2,224
Passenger	4,895	4,185	710

Method

There were over 10,000 passenger cars involved in fatal accidents in 1985 which had both a driver and a right front passenger (both five years or older) for both of whom restraint use was known. When each of these drivers is paired with each of the right front passengers in the same vehicle, there are 10,344 driver-passenger pairs. The pairing results in a small amount of duplication because of people sharing seats. However, because children under five years old are excluded, this duplication is very small. And it has the desired effect of including the same number of drivers as passengers in the analysis.

In many of these cars there was no fatality -- a nonoccupant (such as a pedestrian or bicyclist) or an occupant of another vehicle in the accident was killed. Overall, there were 3,802 drivers and 3,951 passengers killed among the driver-passenger pairs. If fatality risk were not associated with seating position, there would be approximately the same number of fatalities in each position.

The driver fatality odds can be computed as the ratio of driver fatalities to passenger fatalities. The inverse, passenger fatality odds, are computed as the ratio of passenger fatalities to driver fatalities. This can be done for a variety of situations to produce relative fatality odds. This has become a standard method of estimating fatality risk from a data file composed solely of fatal accidents. For this analysis, the fatality odds are compared by victim restraint use to produce estimates of restraint effectiveness in preventing fatalities.

Results

The following table shows the number of driver and right front passenger fatalities in four restraint situations -- where neither was restrained, where only the passenger was restrained, where only the driver was restrained, and where both were restrained. The driver fatality odds are computed as the ratio of driver fatalities to passenger fatalities in each of these four situations. For example, when neither person was restrained, the driver fatality odds are 0.991. (The passenger fatality odds in this situation are the multiplicative inverse, 1.009.) When the driver is restrained (but the passenger is not), the driver fatality odds are substantially lower, 0.421. This difference reflects the usefulness of restraints in preventing fatality. The numbers of fatalities and the fatality odds are shown in the next table for all of the driver-passenger pairs in 1985.

Fatality Odds in Cars with a Driver and a Right Front Passenger
(People Five Years and Older, 1985 Fatal Accidents)

Restraint Used ?		Number of Fatalities		Ratio of Fatalities	
Driver	Passenger	Driver	Passenger	Drivers/ Passengers	Passengers/ Drivers
No	No	3,221	3,251	0.991	1.009
No	Yes	153	77	1.987	0.503
Yes	No	91	216	0.421	2.374
Yes	Yes	337	407	0.828	1.208

Similar results are shown in the next two tables for fatalities not covered and covered, respectively, by mandatory belt use laws.

Fatality Odds in Cars with a Driver and a Right Front Passenger
for States and Months in 1985 without Mandatory Belt Use Laws
(People Five Years and Older, 1985 Fatal Accidents)

Restraint Used ?		Number of Fatalities		Ratio of Fatalities	
Driver	Passenger	Driver	Passenger	Drivers/ Passengers	Passengers/ Drivers
No	No	2,889	2,924	0.988	1.012
No	Yes	111	56	1.982	0.505
Yes	No	68	151	0.450	2.221
Yes	Yes	189	236	0.801	1.249

Fatality Odds in Cars with a Driver and a Right Front Passenger
for States and Months in 1985 Covered by Mandatory Belt Use Laws
(People Five Years and Older, 1985 Fatal Accidents)

Restraint Used ?		Number of Fatalities		Ratio of Fatalities	
Driver	Passenger	Driver	Passenger	Drivers/ Passengers	Passengers/ Drivers
No	No	332	327	1.015	0.985
No	Yes	42	21	2.000	0.500
Yes	No	23	65	0.354	2.826
Yes	Yes	148	171	0.865	1.155

Restraint effectiveness can be estimated as the percentage reduction in the fatality odds for restraint use versus nonuse. For example, consider the summary over both belt law categories, and use the unrestrained passenger as a control for calculating the driver fatality odds. The driver fatality odds are 0.421 for restrained drivers as contrasted with 0.991 for unrestrained drivers. The driver restraint effectiveness is calculated from these data as

$$1 - (0.421 / 0.991) = 1 - 0.42 = 58 \text{ percent.}$$

Restraint effectiveness can be calculated using restrained and unrestrained controls, and for those covered and not covered by belt use laws. The results are shown in the next table. The estimates averaged over control restraint use are simple means; the estimates averaged over seating position are weighted by the total number of fatalities in each seating position.

Estimated Restraint Effectiveness
(People Five Years and Older, 1985 Fatal Accidents)

Subject	Control	Overall	No Law	With Law
Driver	Unrestrained passenger	58 %	54 %	65 %
	Restrained passenger	58 %	60 %	57 %
Passenger	Unrestrained driver	50 %	50 %	49 %
	Restrained driver	49 %	44 %	59 %
Driver	Average	58 %	57 %	61 %
Passenger	Average	50 %	47 %	54 %
Average	Unrestrained control	56 %	53 %	61 %
	Restrained control	56 %	55 %	57 %
Average	Average	56 %	54 %	59 %

Conclusions

The overall estimates (over all states and months) of effectiveness are very similar for unrestrained and restrained controls: both estimates are 58 percent effectiveness for drivers; and 50 percent and 49 percent effectiveness, respectively, for right front passengers. The estimates are more variable within the two subgroups -- people covered by belt use laws and all other people. The belt use law seems to be associated with higher effectiveness estimates, but not consistently and not by a large amount. The estimates of restraint effectiveness averaged over both seating positions and both controls are 59 percent for people subject to a belt use law and 54 percent for other people. The observed difference between seating positions is larger than that between belt law coverage groups.

Although the institution of a mandatory belt use law does not appear to substantially affect the restraint effectiveness estimated by this method, this does not mean that the law has no effect on belt use reporting. It seems likely that the laws result in inflated self-reports of restraint use, as people attempt to protect themselves from insurance losses or legal action. All that has been suggested here is that if there is restraint use misrepresentation, it is occurring fairly consistently across both fatalities and survivors in these accidents.

Lap and Shoulder Belt Effectiveness
by Fatal Accident Crash Direction
October 1986

Lap and Shoulder Belt Effectiveness
by Fatal Accident Crash Direction

S. Partyka
October 1986

Front seat lap and shoulder belt systems are estimated to be 50 percent effective in preventing fatalities, based upon data from the 1982 through 1985 Fatal Accident Reporting System. The estimated effectiveness is greatest in vehicles which rolled over (76 percent) and in vehicles with frontal damage (47 percent). The estimated effectiveness is lower in side impacts (26 percent).

The driver seat belt system appears to be more effective (53 percent effective) than the belt system in the right-front passenger seat (44 percent effective) in preventing fatalities. The difference is greatest in frontal impacts (50 percent effectiveness for drivers versus 38 percent for right-front passengers). There is a smaller difference in side impacts (27 percent effectiveness for drivers versus 22 percent for right-front passengers) and in rollovers (77 percent for drivers versus 75 percent for right-front passengers).

These estimates are consistent with effectiveness estimates derived from other data sources. However, the accuracy of belt use reporting on FARS has not been confirmed by independent investigations -- specifically, belt use may be overreported, particularly in states with mandatory belt use laws.

Data

There were 81,332 outboard front seat car occupant fatalities five years and older during 1982 through 1985. Of these, 61,890 were drivers and 19,442 were right front passengers. The annual data are shown in Table 1. Restraint use is unknown on the Fatal Accident Reporting System for 19 percent of these people, and the amount of unknown data is very consistent over these four years. The unknown data are excluded from most of this analysis.

Table 1: Passenger Car Fatalities, People Five Years and Older

Year	Driver	Passenger	Total
1982	15,340	5,043	20,383
1983	15,167	4,727	19,894
1984	15,873	4,777	20,650
1985	15,510	4,895	20,405
Total	61,890	19,442	81,332

Method

There were about 40,000 passenger cars model years 1974 and later which were involved in fatal accidents during 1982 through 1985 and which had both a driver and a right front passenger, both five years or older, and for both of whom restraint use was known. These vehicles were required by federal law to be equipped with lap and shoulder belt systems in the front outboard seating positions. For purposes of this analysis, a restrained occupant in one of these seating positions is assumed to be using both the lap and shoulder belts provided as standard equipment.

When each of the drivers in these vehicles is paired with each of the right front passengers in the same vehicle, there are 40,168 driver-passenger pairs. The pairing results in a small amount of duplication because of people sharing seats. However, because children under five years old are excluded, this duplication is very small. And it has the desired effect of including the same number of drivers as passengers in the analysis.

In many of these cars there was no fatality -- a nonoccupant (such as a pedestrian or bicyclist) or another vehicle occupant was killed. Overall, there were 11,334 drivers and 11,664 passengers killed among the driver-passenger pairs. Because fatality risk does not vary greatly with seating position, there are approximately the same number of fatalities in each position.

The driver fatality odds can be computed as the ratio of driver fatalities to passenger fatalities. The inverse, passenger fatality odds, are computed as the ratio of passenger fatalities to driver fatalities. This can be done for a variety of situations to produce relative fatality odds. This has become a standard method of estimating fatality risk from a data file composed solely of fatal accidents. For this analysis, the fatality odds are compared by victim restraint use to produce estimates of restraint effectiveness in preventing fatalities.

Results

Table 2 shows the number of driver and right front passenger fatalities in four restraint situations -- where neither was restrained, where only the passenger was restrained, where only the driver was restrained, and where both were restrained. The driver fatality odds are computed as the ratio of driver fatalities to passenger fatalities in each of these four situations. For example, when neither person was restrained, the driver fatality odds are 0.990 for all crash directions combined. When the driver was restrained but the passenger was not, the driver fatality odds are substantially lower, 0.457 in these four years. This difference reflects the usefulness of restraints in preventing fatality. The numbers of fatalities and the fatality odds are shown in Table 2 by crash direction.

Restraint effectiveness can be estimated as the percentage reduction in the fatality odds for restraint use versus nonuse. For example, consider the summary over crash direction, and use the unrestrained passenger as a control for calculating the driver fatality odds. The driver fatality odds are 0.457 for restrained drivers as contrasted with 0.990 for unrestrained drivers. The driver restraint effectiveness is calculated from these data as

$$1 - (0.457 / 0.990) = 1 - 0.46 = 54 \text{ percent.}$$

Restraint effectiveness can be calculated using restrained and unrestrained controls, for each crash direction separately and for all directions combined. The results are shown in Table 3. The estimates averaged over control restraint use are simple means; the estimates averaged over seating position are weighted by the total number of fatalities in each seating position, from Table 1.

Conclusion

The effectivenes estimate is highest for occupants of vehicles which rolled over (76 percent). The four separate estimates (produced for drivers and right-front passengers using restrained and unrestrained controls) show consistent results -- all are in the range of 72 to 79 percent effectiveness. Thus, the high effectiveness estimate for rollovers appears reliable.

Restraints appear to be less effective in frontal impacts -- the overall estimate is 47 percent. The four separate estimates (produced from the categories of seating position and restraint use of the control occupant) are in the range of 34 to 54 percent. The driver restraint appears to be more effective than the right-front passenger restraint (50 percent effective for drivers versus only 38 percent effective for right-front passengers).

In side impacts, restraints are estimated to be 26 percent effective, but the four separate estimates range from 10 to 39 percent effective. There is too much variability in the estimates to determine the relative effectiveness of driver versus right-front passenger restraints.

The small number of fatalities in rear impacts precludes a reliable restraint use estimate. There is no apparent pattern to the variety of estimates produced by the four separate subject-control groups. These estimates range from -35 to 60 percent effective.

Table 2: Fatalities in 1974 and Later Model Year Cars
When Both a Driver and a Right Front Passenger Are Present
(People Five Years and Older in Fatal Accidents)

Damage	Restraint Used ?		Number of Fatalities		Ratio of Fatalities	
	Driver	Passenger	Driver	Passenger	Drivers/ Passengers	Passengers/ Drivers
Front	No	No	4,146	4,131	1.004	0.996
	No	Yes	120	68	1.765	0.567
	Yes	No	94	173	0.543	1.840
	Yes	Yes	252	308	0.818	1.222
Side	No	No	2,659	3,239	0.821	1.218
	No	Yes	60	66	0.909	1.100
	Yes	No	61	121	0.504	1.984
	Yes	Yes	238	306	0.778	1.286
Rear	No	No	246	268	0.918	1.089
	No	Yes	9	9	1.000	1.000
	Yes	No	7	13	0.538	1.857
	Yes	Yes	8	20	0.400	2.500
Rollover	No	No	2,790	2,275	1.226	0.815
	No	Yes	112	26	4.308	0.232
	Yes	No	31	122	0.254	3.935
	Yes	Yes	88	78	1.128	0.886
Unknown	No	No	353	379	-	-
	No	Yes	13	14	-	-
	Yes	No	7	9	-	-
	Yes	Yes	40	39	-	-
Total	No	No	10,194	10,292	0.990	1.010
	No	Yes	314	183	1.716	0.583
	Yes	No	200	438	0.457	2.190
	Yes	Yes	626	751	0.834	1.200

Table 3: Estimated Restraint Effectiveness, Percent Fatality Reduction
(People Five Years and Older in Fatal Accidents)

Subject	Control	Front	Side	Rear	Roll	Total
Driver	Unrestrained passenger	46	39	41	79	54
	Restrained passenger	54	14	60	74	51
Passenger	Unrestrained driver	43	10	8	72	42
	Restrained driver	34	35	-35	77	45
Driver	Average	50	27	51	77	53
Passenger	Average	38	22	-13	75	44
Average	Unrestrained control	45	32	33	77	51
	Restrained control	49	19	37	75	50
Average	Average	47	26	35	76	50

Belt Effectiveness in Fatal Accidents

November 1986

Belt Effectiveness in Fatal Accidents

S. Partyka

Front seat lap and shoulder safety belts are estimated to be 50 percent effective in preventing fatalities, based upon data from the 1982 through 1985 Fatal Accident Reporting System. The estimated effectiveness varies by year (50 percent in 1982, 43 percent in 1983, 45 percent in 1984, and 56 percent in 1985), but there is no clear trend in the estimates.

The driver seat belt appears to be more effective (53 percent effective) than the belt in the right-front passenger seat (44 percent effective) in preventing fatalities. There are differences in the magnitude of the annual effectiveness estimates, but the greater effectiveness for the driver appears each year. It may be the result of differences in the vehicle interior for these seating positions, differences in the people by seating position, or reporting biases.

These estimates are consistent with effectiveness estimates derived from other data sources. However, the accuracy of belt use reporting on FARS has not been confirmed by independent investigations -- specifically, belt use may be overreported, particularly in states with mandatory belt use laws.

Data

There were 81,332 outboard front seat car occupant fatalities five years and older during 1982 through 1985. Of these, 61,890 were drivers and 19,442 were right front passengers. The annual data are shown in Table 1. Belt use is unknown on the Fatal Accident Reporting System for 19 percent of these people, and the amount of unknown data is very consistent over these four years. The unknown data are excluded from most of this analysis.

Table 1: Passenger Car Fatalities, People Five Years and Older

Year	Driver	Passenger	Total
1982	15,340	5,043	20,383
1983	15,167	4,727	19,894
1984	15,873	4,777	20,650
1985	15,510	4,895	20,405
Total	61,890	19,442	81,332

Method

There were about 40,000 passenger cars model years 1974 and later which were involved in fatal accidents during 1982 through 1985 and which had both a driver and a right front passenger, both five years or older, and for both of whom belt use was known. When each of these drivers is paired with each of the right front passengers in the same vehicle, there are 40,168 driver-passenger pairs. The pairing results in a small amount of duplication because of people sharing seats. However, because children under five years old are excluded, this duplication is very small. And it has the desired effect of including the same number of drivers as passengers in the analysis.

In many of these cars there was no fatality -- a nonoccupant (such as a pedestrian or bicyclist) or another vehicle occupant was killed. Overall, there were 11,334 drivers and 11,664 passengers killed among the driver-passenger pairs. Because fatality risk does not vary greatly with seating position, there are approximately the same number of fatalities in each position.

The driver fatality odds can be computed as the ratio of driver fatalities to passenger fatalities. The inverse, passenger fatality odds, are computed as the ratio of passenger fatalities to driver fatalities. This can be done for a variety of situations to produce relative fatality odds. This has become a standard method of estimating fatality risk from a data file composed solely of fatal accidents. For this analysis, the fatality odds are compared by victim belt use to produce estimates of belt effectiveness in preventing fatalities.

Results

Table 2 shows the number of driver and right front passenger fatalities in four situations -- where neither was belted, where only the passenger was belted, where only the driver was belted, and where both were belted. The driver fatality odds are computed as the ratio of driver fatalities to passenger fatalities in each of these four situations. For example, when neither person was belted, the driver fatality odds are 0.990 for the four years combined. (The passenger fatality odds in this situation are the multiplicative inverse, 1.010.) When the driver was belted but the passenger was not, the driver fatality odds are substantially lower, 0.457 in these four years. This difference reflects the utility of belts in preventing fatality. The numbers of fatalities and the fatality odds are shown in Table 2 for each of the four years separately and for the four years combined.

Safety belt effectiveness can be estimated as the percentage reduction in the fatality odds for belt use versus nonuse. For example, consider the summary over all four years, and use the unbelted passenger as a control for calculating the driver fatality odds. The driver fatality odds are 0.457 for belted drivers as contrasted with 0.990 for unbelted drivers. The driver belt effectiveness is calculated from these data as

$$1 - (0.457 / 0.990) = 1 - 0.46 = 54 \text{ percent.}$$

Safety belt effectiveness can be calculated using belted and unbelted controls, for each year separately and for all four years combined. The results are shown in Table 3. The estimates averaged over control belt use are simple means; the estimates averaged over seating position are weighted by the total number of fatalities in each seating position, from Table 1.

Conclusion

The effectiveness estimates are very similar for unbelted and belted controls: over all four years the estimates are 54 and 51 percent, respectively, for drivers; and 42 and 45 percent, respectively, for right front passengers. The estimate is highest for 1985, but there is no clear trend towards higher belt effectiveness estimates over time -- the second highest estimate was for 1982. These results are consistent with the agency's estimate that lap and shoulder belts are between 40 and 50 percent effective in preventing fatalities.

The estimated effectiveness is consistently higher for drivers than for right front passengers -- the overall estimate is 53 percent for drivers and only 44 percent for right front passengers. This discrepancy will be explored in subsequent research. The possible explanations include reporting errors in the determination of belt use, differences in the characteristics of the individuals sitting in the right front seats (they are more often women and children), differences in the interior design (drivers sit very close to a steering wheel), and differences in the characteristics of the crash (right side crashes tend to be more severe than crashes into the left side).

Table 2: Fatalities in 1974 and Later Model Year Cars
When Both a Driver and a Right Front Passenger Are Present
(People Five Years and Older in Fatal Accidents)

	Safety Belt Used ?		Number of Fatalities		Ratio of Fatalities	
Year	Driver	Passenger	Driver	Passenger	Drivers/ Passengers	Passengers/ Drivers
1982	No	No	2,554	2,567	0.995	1.005
	No	Yes	40	23	1.739	0.575
	Yes	No	29	61	0.475	2.103
	Yes	Yes	72	87	0.828	1.208
1983	No	No	2,401	2,507	0.958	1.044
	No	Yes	53	33	1.606	0.623
	Yes	No	38	69	0.551	1.816
	Yes	Yes	97	116	0.836	1.196
1984	No	No	2,617	2,628	0.996	1.004
	No	Yes	80	56	1.429	0.700
	Yes	No	51	111	0.459	2.176
	Yes	Yes	138	166	0.831	1.203
1985	No	No	2,622	2,590	1.012	0.988
	No	Yes	141	71	1.986	0.504
	Yes	No	82	197	0.416	2.402
	Yes	Yes	319	382	0.835	1.197
Total	No	No	10,194	10,292	0.990	1.010
	No	Yes	314	183	1.716	0.583
	Yes	No	200	438	0.457	2.190
	Yes	Yes	626	751	0.834	1.200

Table 3: Estimated Belt Effectiveness, Percent Fatality Reduction
(People Five Years and Older in Fatal Accidents)

Subject	Control	1982	1983	1984	1985	Total
Driver	Unbelted passenger	52	42	54	59	54
	Belted passenger	52	48	42	58	51
Passenger	Unbelted driver	43	40	30	49	42
	Belted driver	43	34	45	50	45
Driver	Average	52	45	48	58	53
Passenger	Average	43	37	38	50	44
Average	Unbelted control	50	42	48	57	51
	Belted control	50	45	42	56	50
Average	Average	50	43	45	56	50

Are Belts More Effective for Drivers
or for Right-Front Passengers?
April 1987

Are Belts More Effective for Drivers or for Right-Front Passengers?
Susan Partyka
April 1987

Problem

The 1982 through 1985 Fatal Accident Reporting System (FARS) produces estimates that lap-and-shoulder belts are

53 percent effective in preventing driver fatality and
44 percent effective in prevent right-front passenger fatality.

These results were obtained by computing relative fatality odds in fatal car accidents ("Belt Effectiveness in Fatal Accidents," S. Partyka, November 1986). Belts appear to be more useful for drivers than for right-front passengers.

In contrast, the British belt law was associated with a larger injury decrease (both at the hospital-admitted and hospital-not-admitted level) among right-front passengers than among drivers. Based on data on surviving transported accident victims obtained from 15 British hospitals, there was a

23.2 percent decline in driver hospital admissions and a
43.1 percent decline in right-front passenger hospital admissions.

Among other injured accident victims seen at these hospitals, there was a

10.2 percent decline in drivers not admitted and a
21.9 percent decline in right-front passengers not admitted.

Thus, the British study ("The Medical Efffects of Seat Belt Legislation in the United Kingdom," W. Rutherford et al, 1985) indicates that belt laws are more useful for right-front passengers than for drivers.

The problem addressed here is to reconcile these two antagonistic results.

Explanation

There are two major methodological differences between the FARS and the British studies. First, the FARS results are about preventing fatality. The British results are about preventing injury. This is an important distinction. Half the difference between the FARS and British results can be explained by this factor alone.

Second, the FARS results are about belt effectiveness. The British results are about belt law effectiveness. Several components of this difference can be addressed from the data, others can be speculated about, and others probably cannot be identified from the data. This factor probably explains the remainder of the difference in the results of the two studies.

Fatality versus Injury Effectiveness

Belt effectiveness in fatality prevention was estimated from FARS by comparing fatality odds ratios of belted and unbelted people. Similar effectiveness estimates can be computed for other injury levels from the FARS data. Because FARS excludes the majority of injury cases (those that occurred in nonfatal accidents), the results are not necessarily representative of overall belt effectiveness in preventing injury. Still, the results for drivers compared to right-front passengers are probably useful for the direction and magnitude of the effectiveness differences.

Table 1 is reproduced from the FARS belt effectiveness study. Tables 2 through 5 are comparable results for four different injury comparisons, as follows:

Table 1 is fatality reduction in fatal accidents;
Table 2 is fatality/incapacitating injury reduction in fatal accidents;
Table 3 is fatality/incapacating/evident injury reduction in fatal accidents;
Table 4 is incapacitating injury reduction in fatal accidents in cars without a fatality; and
Table 5 is incapacitating/evident injury reduction in fatal accidents in cars without a fatality.

The results are summarized here.

Accident Type and Injury Measure Used	Effectiveness for Driver	Effectiveness for RF Passenger
FARS data		
In all cars in fatal accidents --		
Fatality reduction	53 %	44 %
Fatality and incapacitating injury reduction	25 %	24 %
Evident and greater injury reduction	8 %	7 %
In cars without a fatality in fatal accidents --		
Incapacitating injury reduction	19 %	23 %
Evident and incapacitating injury reduction	4 %	7 %
British data		
Taken to one of 15 hospitals --		
Reduction in admissions	23.2 %	43.1 %
Reduction in nonadmissions	10.3 %	21.9 %

Effectiveness is 9 percentage points higher for drivers (53 percent) than for right-front passengers (44 percent) when fatality is the measure. When fatality/incapacitating injury is used, the advantage to the driver (25 percent) as compared to the right-front passenger (24 percent) disappears. Similarly for evident and greater injury -- the effectiveness is estimated at 8 percent for drivers and 7 percent for right-front passengers.

Because these are all fatal accidents, these three results are largely about fatality reduction, even though lesser injuries are counted. To get around this, a subset of the cars -- those that had no occupant killed in the fatal accident -- was used. These results show that the right-front passenger belt is more effective (23 percent) than the driver belt (19 percent effective) in preventing incapacitating injury in these severe accidents. Also, the right-front passenger belt is more effective (7 percent) than the driver belt (4 percent effective) in preventing evident and greater injury among survivors of these severe accidents.

Not all injury accidents are represented here -- only those serious enough to kill someone else (someone outside that car) in the accident. Therefore, these estimates are useful for comparing the effects for the two seating positions, but need not be good estimates of overall belt effectivenesss for these injuries. The results of comparing belt injury-reducing effectiveness from FARS are closer to the British results than the fatality analysis suggested.

Belt versus Belt Law Effectiveness

The British noted the drop in the number of injuries after the law took effect, but noted (page 31 of their report) that there might have been a shift in occupancy from the right-front seat to the rear seat. Another possibility is that there was an absolute decrease in car occupancy; this would reduce the number of passenger injuries relative to the number of driver injuries.

The FARS data have the analytical advantage that belt laws are in effect in some, but not all, states. This provides a basis for comparing the driver and right-front passenger experiences. Two years of FARS data were used: 1984 (when only one state had a belt law for one month, without fines or other penalties) and 1986 (when 14 states had belt laws for at least eleven months). The changes in the number of fatalities by seat position in the belt-law and non-belt-law states are shown below.

State Type and Seating Position	1984	1986	Change
Fourteen belt-law states			
Driver	6,390	6,361	- 0.5%
Right-front passenger	2,005	2,127	+ 6.1%
All other states			
Driver	9,501	10,068	+ 6.0%
Right-front passenger	2,938	3,451	+17.5%
Belt-law states adjusted for other-state experience			
Driver			- 6.5%
Right-front passenger			-11.4%

Two things are worth noting from this table. First, a belt law is no guarantee that fatalities will decrease. Front-seat passenger fatalities increased by 6.1 percent in belt-law states, for economic and other non-belt related reasons. Thus, a simple before-after comparison of counts can give misleadinng results.

Second, right-front passenger fatalities increased more in non-belt-law states than did driver fatalities in these states. Thus, in this country there may have been an increase in car occupancy from 1984 to 1986. If this represents a national trend, then the belt-law state data should be adjusted for the trend. Doing so yields results more comparable to the British experience -- the belt laws were associated with a fatality decrease that was 4.9 percentage points higher among right-front passenger than among drivers. This may mean that people moved from the front to the rear seats after the law requiring front seat belt use was passed, that vehicle occupancy increased more in non-belt-law states than in belt-law states, that belt use increased more among passengers than among drivers (perhaps because children are passengers by not drivers), or that right-front passenger belts are actually (despite the results of the fatality odds comparison) more effective than driver belts.

Other Factors

A small difference between the FARS fatality odds study and the British study is that children under five years were excluded from the former (because of the statistical complication caused by the prevalence of child safety seats here), but included in the latter. Belts may be especially effective in preventing child fatality by preventing child ejection in low-severity crashes.

Another difference is that the FARS fatality odds study was limited, by its method, to cars with at least two occupants (a driver and a right-front passsenger). It is possible that driver belt effectiveness is lower for lone drivers than for drivers with passengers. For example, lone drivers may get in more serious crashes with greater intrusion; here the belt is much less effective. This would explain some of the discrepancy with the British results. The comparison of the FARS fatality odds data with the FARS before-after with-without belt law data presented here is consistent with this idea.

Another difference is that only the FARS fatality odds study depended on reported belt use for its results. If belt use reporting is biased, and especially if the bias is different for drivers than for right-front passengers, this would produce errors in the relative belt use benefits calculated from the data. If much of the FARS survivor belt use data is driver-reported, they may indeed give more optimistic results for driver belts than for right-front passenger belts. Again, this is consistent with the FARS before-after with-without belt law comparisons presented here.

The importance of other differences between the British and the FARS belt experiences can only be speculated upon from these data. The British drive different vehicles under different conditions. However, the factors detailed above potentially explain most of the differences in the study results. It is not clear in which direction these other hypotesized factors would tend.

Table 1:
Fatalities in 1974 and Later Model Year Cars
When Both a Driver and a Right Front Passenger Are Present
(People Five Years and Older in Fatal Accidents)

Year	Safety Belt Used ? Driver	Safety Belt Used ? Passenger	Number of Deaths Driver	Number of Deaths Passenger	Ratio of Fatalities Drivers/ Passengers	Ratio of Fatalities Passengers/ Drivers
1982	No	No	2,554	2,567	0.995	1.005
	No	Yes	40	23	1.739	0.575
	Yes	No	29	61	0.475	2.103
	Yes	Yes	72	87	0.828	1.208
1983	No	No	2,401	2,507	0.958	1.044
	No	Yes	53	33	1.606	0.623
	Yes	No	38	69	0.551	1.816
	Yes	Yes	97	116	0.836	1.196
1984	No	No	2,617	2,628	0.996	1.004
	No	Yes	80	56	1.429	0.700
	Yes	No	51	111	0.459	2.176
	Yes	Yes	138	166	0.831	1.203
1985	No	No	2,622	2,590	1.012	0.988
	No	Yes	141	71	1.986	0.504
	Yes	No	82	197	0.416	2.402
	Yes	Yes	319	382	0.835	1.197
Total	No	No	10,194	10,292	0.990	1.010
	No	Yes	314	183	1.716	0.583
	Yes	No	200	438	0.457	2.190
	Yes	Yes	626	751	0.834	1.200

Subject	Control	Calculated Effectiveness 1982	1983	1984	1985	Total
Driver	Unbelted passenger	52	42	54	59	54
	Belted passenger	52	48	42	58	51
Passenger	Unbelted driver	43	40	30	49	42
	Belted driver	43	34	45	50	45
Driver	Average	52	45	48	58	53
Passenger	Average	43	37	38	50	44
Average	Unbelted control	50	42	48	57	51
	Belted control	50	45	43	56	50
Average	Average	50	43	45	56	51

Table 2:
Fatalities and Incapacitating Injuries
in 1974 and Later Model Year Cars
When Both a Driver and a Right Front Passenger Are Present
(People Five Years and Older in Fatal Accidents)

Year	Safety Belt Used ? Driver	Safety Belt Used ? Passenger	Number of Injuries Driver	Number of Injuries Passenger	Ratio of Injuries Drivers/ Passengers	Ratio of Injuries Passengers/ Drivers
1982	No	No	4,255	4,384	0.971	1.030
	No	Yes	54	45	1.200	0.833
	Yes	No	64	85	0.753	1.328
	Yes	Yes	130	137	0.949	1.054
1983	No	No	4,088	4,292	0.952	1.050
	No	Yes	80	68	1.176	0.850
	Yes	No	77	102	0.755	1.325
	Yes	Yes	186	205	0.907	1.102
1984	No	No	4,373	4,535	0.964	1.037
	No	Yes	119	105	1.133	0.882
	Yes	No	104	154	0.675	1.481
	Yes	Yes	285	307	0.928	1.077
1985	No	No	4,384	4,495	0.975	1.025
	No	Yes	205	147	1.395	0.717
	Yes	No	201	282	0.713	1.403
	Yes	Yes	644	649	0.992	1.008
Total	No	No	17,100	17,706	0.966	1.035
	No	Yes	458	365	1.255	0.797
	Yes	No	446	623	0.716	1.397
	Yes	Yes	1,245	1,298	0.959	1.043

Subject	Control	Calculated Effectiveness 1982	1983	1984	1985	Total
Driver	Unbelted passenger	22	21	30	27	26
	Belted passenger	21	23	18	29	24
Passenger	Unbelted driver	19	19	15	30	23
	Belted driver	21	17	27	28	25
Driver	Average	22	22	24	28	25
Passenger	Average	20	18	21	29	24
Average	Unbelted control	22	20	26	28	25
	Belted control	21	21	20	29	24
Average	Average	21	21	23	28	25

Table 3:
Evident through Fatal Injuries
in 1974 and Later Model Year Cars
When Both a Driver and a Right Front Passenger Are Present
(People Five Years and Older in Fatal Accidents)

	Safety Belt Used ?		Number of Injuries		Ratio of Injuries	
Year	Driver	Passenger	Driver	Passenger	Drivers/ Passengers	Passengers/ Drivers
1982	No	No	5,296	5,441	0.973	1.027
	No	Yes	65	61	1.066	0.938
	Yes	No	100	110	0.909	1.100
	Yes	Yes	173	180	0.961	1.040
1983	No	No	5,089	5,211	0.977	1.024
	No	Yes	97	96	1.010	0.990
	Yes	No	111	120	0.925	1.081
	Yes	Yes	257	263	0.977	1.023
1984	No	No	5,344	5,517	0.969	1.032
	No	Yes	146	146	1.000	1.000
	Yes	No	160	187	0.856	1.169
	Yes	Yes	375	388	0.966	1.035
1985	No	No	5,328	5,472	0.974	1.027
	No	Yes	241	227	1.062	0.942
	Yes	No	290	326	0.890	1.124
	Yes	Yes	866	910	0.952	1.051
Total	No	No	21,057	21,641	0.973	1.028
	No	Yes	549	530	1.036	0.965
	Yes	No	661	743	0.890	1.124
	Yes	Yes	1,671	1,741	0.960	1.042

		Calculated Effectiveness				
Subject	Control	1982	1983	1984	1985	Total
Driver	Unbelted passenger	7	5	12	9	9
	Belted passenger	10	3	3	10	7
Passenger	Unbelted driver	9	3	3	8	6
	Belted driver	5	5	11	7	7
Driver	Average	8	4	8	10	8
Passenger	Average	7	4	7	7	7
Average	Unbelted control	7	5	10	9	8
	Belted control	9	4	5	9	7
Average	Average	8	4	7	9	8

Table 4:
Incapacitating Injuries in Vehicles without Fatalities
in 1974 and Later Model Year Cars
When Both a Driver and a Right Front Passenger Are Present
(People Five Years and Older in Fatal Accidents)

	Safety Belt Used ?		Number of Injuries		Ratio of Injuries	
Year	Driver	Passenger	Driver	Passenger	Drivers/ Passengers	Passengers/ Drivers
1982	No	No	433	483	0.896	1.115
	No	Yes	3	3	1.000	1.000
	Yes	No	9	8	1.125	0.889
	Yes	Yes	18	18	1.000	1.000
1983	No	No	402	440	0.914	1.095
	No	Yes	10	10	1.000	1.000
	Yes	No	6	7	0.857	1.167
	Yes	Yes	32	39	0.821	1.219
1984	No	No	429	471	0.911	1.098
	No	Yes	9	9	1.000	1.000
	Yes	No	10	19	0.526	1.900
	Yes	Yes	57	62	0.919	1.088
1985	No	No	458	458	1.000	1.000
	No	Yes	22	17	1.294	0.773
	Yes	No	27	40	0.675	1.481
	Yes	Yes	99	93	1.065	0.939
Total	No	No	1,722	1,852	0.930	1.075
	No	Yes	44	39	1.128	0.886
	Yes	No	52	74	0.703	1.423
	Yes	Yes	206	212	0.972	1.029

		Calculated Effectiveness				
Subject	Control	1982	1983	1984	1985	Total
Driver	Unbelted passenger	-25	6	42	32	24
	Belted passenger	0	18	8	18	14
Passenger	Unbelted driver	10	9	9	23	18
	Belted driver	-13	-4	43	37	28
Driver	Average	-13	12	25	25	19
Passenger	Average	-1	2	26	30	23
Average	Unbelted control	-17	7	34	30	23
	Belted control	-3	13	16	22	17
Average	Average	-10	10	25	26	20

Table 5:
Evident through Incapacitating Injuries in Vehicles without Fatalities
in 1974 and Later Model Year Cars
When Both a Driver and a Right Front Passenger Are Present
(People Five Years and Older in Fatal Accidents)

	Safety Belt Used ?		Number of Injuries		Ratio of Injuries	
Year	Driver	Passenger	Driver	Passenger	Drivers/ Passengers	Passengers/ Drivers
1982	No	No	835	899	0.929	1.077
	No	Yes	7	7	1.000	1.000
	Yes	No	21	21	1.000	1.000
	Yes	Yes	43	46	0.935	1.070
1983	No	No	793	834	0.951	1.052
	No	Yes	18	19	0.947	1.056
	Yes	No	17	18	0.944	1.059
	Yes	Yes	71	69	1.029	0.972
1984	No	No	782	849	0.921	1.086
	No	Yes	20	20	1.000	1.000
	Yes	No	28	34	0.824	1.214
	Yes	Yes	106	103	1.029	0.972
1985	No	No	797	846	0.942	1.061
	No	Yes	42	42	1.000	1.000
	Yes	No	55	65	0.846	1.182
	Yes	Yes	223	240	0.929	1.076
Total	No	No	3,207	3,428	0.936	1.069
	No	Yes	87	88	0.989	1.011
	Yes	No	121	138	0.877	1.140
	Yes	Yes	443	458	0.967	1.034

		Calculated Effectiveness				
Subject	Control	1982	1983	1984	1985	Total
Driver	Unbelted passenger	-8	1	11	10	6
	Belted passenger	7	-9	-3	7	2
Passenger	Unbelted driver	7	-0	8	6	5
	Belted driver	-7	8	20	9	9
Driver	Average	-1	-4	4	9	4
Passenger	Average	0	4	14	7	7
Average	Unbelted control	-4	0	10	9	6
	Belted control	3	-5	3	8	4
Average	Average	-0	-2	6	8	5

Belt Effectiveness in Pickup Trucks and Passenger Cars
by Crash Direction and Accident Year
May 1988

Belt Effectiveness in Pickup Trucks and Passenger Cars
by Crash Direction and Accident Year
May 1988

Results

Front seat lap and shoulder belt systems are estimated to be 69 percent effective in preventing fatality in the front seats of pickup trucks, based on data from the 1982 through 1987 Fatal Accident Reporting System (FARS). This is higher than the 55 percent estimated for passenger cars during these years.

Lap and shoulder belts appear to be particularly effective in preventing fatality in rollovers. It is estimated that front seat lap and shoulder belts can prevent 81 percent of pickup truck rollover fatalities and 75 percent of passenger car rollover fatalities.

Belt effectiveness is consistently high for frontal impacts: 56 percent for pickup truck front seat occupants and 51 percent for passenger car front seat occupants. In frontal impacts, belt effectiveness is estimated as slightly lower for drivers than for passengers of pickup trucks, but slightly higher for drivers than for passengers of passenger cars.

Pickup truck front seat belts are estimated to be more effective in left side impacts (62 percent effective for drivers, 63 percent effective for right front passengers) than in right side impacts (31 percent effective for drivers, 27 percent effective for right front passengers).

In contrast, passenger car front seat belts are estimated to be more effective in impacts away from the occupant. This applies to both the driver (56 percent effective in right side impacts but 22 percent effective in left side impacts) and the right front passenger (35 percent in right side impacts but 41 percent effective in left side impacts).

The small number of belted pickup truck occupant fatalities until very recently precludes meaningful comparison of estimated belt effectiveness by accident year. Passenger car belt effectiveness estimates tend to be higher for more recent (1985 through 1987) than for previous (1982 through 1984) years. However, there is no clear trend. The later estimates may reflect better reporting of a priority issue or biases introduced by seat belt laws.

Data

In mid-May 1988, the 1982 through 1986 FARS data files were complete. The 1987 data file (Version 87-161) was about 98 percent complete. Two vehicle groups, six damage types, two seating positions, two restraint categories, and two injury outcomes were used in the comparisons. Each of these was defined in terms of FARS data elements.

Pickup trucks have Body Types 50-51, 53-55, 58-59
and are required to be equipped with lap and shoulder belts
for Model Years 1976 and later.
Passenger cars have Body Types 1-11, 67
and are required to be equipped with lap and shoulder belts
for Model Years 1974 and later.

Damage is defined as
"Rollover" for Rollover data element values 1-2.
Otherwise the damage is defined as
"Front" for Principal Impact values 11, 12, 1;
"Right" for Principal Impact values 2-4;
"Rear" for Principal Impact values 5-7;
"Left" for Principal Impact values 8-10.
Otherwise the damage is categorized as "Other/unknown".

Drivers have Seating Position 11.
Right front passengers have Seating Position 13.

People are restrained if
Manual Restraint is coded 1-8 or
Automatic Restraint is coded 1 or 3.
People are unrestrained if
Manual Restraint is coded 0 and
Automatic Restraint is not coded 1 and not coded 3.

Fatalities have Injury Severity coded 4.
Survivors have any other coded Injury Severity.

For a vehicle to be included in the analysis, it had to have a driver over four years old with belt use coded and a right front passenger over four years old with belt use coded. This created

10,666 driver-passenger pairs in pickup trucks and
50,955 driver-passenger pairs in passenger cars.

These pairs are the basis of all comparisons in this report.

Method

Beginning with model year 1974 for passenger cars and 1976 for pickup trucks, all driver and right front passenger seats were required by federal regulation to be equipped with a lap and shoulder belt. In this analysis, any occupant reported to have been restrained in one of these seats was assumed to have been using a lap and shoulder belt system.

This analysis uses the matched-pairs technique used by Leonard Evans of General Motors and Charles Kahane of NHTSA on FARS data. Briefly, the method involves computing and comparing fatality odds. For example, in pickup trucks that rolled over during these six years there were

> 1,608 driver fatalities involving
> an unrestrained driver and
> an unrestrained right front passenger; and
>
> 1,376 right front passenger fatalities involving
> an unrestrained driver and
> an unrestrained right front passenger.
>
> The fatality odds are
> 1,608 / 1,376 = 1.169.

There also were

> 20 driver fatalities involving
> a restrained driver and
> an unrestrained right front passenger; and
>
> 69 right front passenger fatalities involving
> a restrained driver and
> an unrestrained right front passenger.
>
> The fatality odds are
> 20 / 69 = 0.290.

If these odds can be interpreted as fatality rates (driver fatalities standardized by companion unrestrained right front passenger fatalities), then driver lap and shoulder belts are estimated to be

$$(1.169 - 0.290) / 1.169 = 75 \text{ percent effective}$$

in preventing driver fatality in rollovers.

The same calculations can be made using restrained right front passengers as the control, producing an estimate that belts are 89 percent effective in preventing driver fatality in rollovers. The calculations were performed for right front passengers (using drivers as controls), by crash direction, and by accident year.

Results

The fatality counts and fatality odds for pickup trucks (Table 1) and passenger cars (Table 2) were computed by crash direction. Tables 3 and 4 show the estimated belt effectiveness for pickup trucks and passenger cars, respectively. The average belt effectiveness for each seat position was calculated as the midpoint of the estimates obtained from the restrained and unrestrained controls. The average belt effectiveness across seat positions was calculated as the midpoint of the estimates obtained for the driver and right front passenger.

Seat belts are estimated to be most effective in rollovers: 81 percent for pickup trucks and 75 percent for passenger cars. Pickup truck lap and shoulder belts appear to be more effective in preventing fatalities from left side impacts than from right side impacts. Occupants seated on the same side as the impact (and so subject to intrusion at that position) appear to benefit almost as much from their belts as occupants seated on the side away from the impact.

This is a very different result than that obtained for passenger cars. Here, it seems clear that occupants seated on the side away from the impact benefit much more than occupants seated on the same side as the impact. The reasons for this interesting difference are not clear from these data alone.

Fatality counts and fatality odds were computed for each year separately (Tables 5 and 6), but for all crash types combined. Until the most recent few years, belt use in pickup trucks was very low. Annual belt effectiveness estimates are subject to large random errors (Table 7). The results for passenger cars are more stable (Table 8). The annual results indicate that belt effectiveness estimates may be increasing. This may reflect improvements in belt use coding by the police or biases caused by laws that require belt use in passenger vehicles.

Table 1: Fatalities in the Front Seats of Pickup Trucks
Model Years 1976 and Later
by Principal Impact Point

Impact Point	Safety Belt Used		Number of Deaths		Ratio of Injuries	
	Driver	Passenger	Driver	Passenger	Drivers/ Passengers	Passengers /Drivers
Rollover	No	No	1,608	1,376	1.169	0.856
	No	Yes	57	6	9.500	0.105
	Yes	No	20	69	0.290	3.450
	Yes	Yes	35	34	1.029	0. 71
Front	No	No	1,028	934	1.101	0.909
	No	Yes	32	14	2.286	0.438
	Yes	No	16	37	0.432	2.313
	Yes	Yes	75	58	1.293	0.773
Right	No	No	120	311	0.386	2.592
	No	Yes	3	6	0.500	2.000
	Yes	No	4	16	0.250	4.000
	Yes	Yes	13	36	0.361	2.769
Rear	No	No	28	31	0.903	1.107
	No	Yes	3	0	*	0.000
	Yes	No	2	2	1.000	1.000
	Yes	Yes	1	0	*	0.000
Left	No	No	270	108	2.500	0.400
	No	Yes	7	1	7.000	0.143
	Yes	No	5	5	1.000	1.000
	Yes	Yes	23	9	2.556	0.391
Other/unk	No	No	84	133	0.632	1.583
	No	Yes	1	0	*	0.000
	Yes	No	1	6	0.167	6.000
	Yes	Yes	4	6	0.667	1.500
Total	No	No	3,138	2,893	1.085	0.922
	No	Yes	103	27	3.815	0.262
	Yes	No	48	135	0.356	2.813
	Yes	Yes	151	143	1.056	0.947

* Division by zero -- not defined

Table 2: Fatalities in the Front Seats of Passenger Cars
Model Years 1974 and Later
by Principal Impact Point

Impact Point	Safety Belt Used: Driver	Safety Belt Used: Passenger	Number of Deaths: Driver	Number of Deaths: Passenger	Ratio of Injuries: Drivers/ Passengers	Ratio of Injuries: Passengers /Drivers
Rollover	No	No	4,456	3,669	1.214	0.823
	No	Yes	303	70	4.329	0.231
	Yes	No	79	298	0.265	3.772
	Yes	Yes	280	256	1.094	0.914
Front	No	No	6,326	6,232	1.015	0.985
	No	Yes	301	159	1.893	0.528
	Yes	No	196	434	0.452	2.214
	Yes	Yes	805	896	0.898	1.113
Right	No	No	1,265	3,718	0.340	2.939
	No	Yes	57	121	0.471	2.123
	Yes	No	33	244	0.135	7.394
	Yes	Yes	188	814	0.231	4.330
Rear	No	No	369	420	0.879	1.138
	No	Yes	17	14	1.214	0.824
	Yes	No	18	33	0.545	1.833
	Yes	Yes	57	85	0.671	1.491
Left	No	No	2,661	1,026	2.594	0.386
	No	Yes	125	29	4.310	0.232
	Yes	No	97	49	1.980	0.505
	Yes	Yes	577	166	3.476	0.288
Other/unk	No	No	528	544	0.971	1.030
	No	Yes	34	22	1.545	0.647
	Yes	No	16	34	0.471	2.125
	Yes	Yes	86	84	1.024	0.977
Total	No	No	15,605	15,609	1.000	1.000
	No	Yes	837	415	2.017	0.496
	Yes	No	439	1,092	0.402	2.487
	Yes	Yes	1,993	2,301	0.866	1.155

Table 3: Pickup Truck Front Seat Belt Effectiveness
Model Years 1976 and Later
by Principal Impact Point

Subject	Control	Calculated Effectiveness Roll	Front	Right	Rear	Left	Other	Total
Driver	Unbelted passenger	75	61	35	-11	60	74	67
	Belted passenger	89	43	28	*	63	*	72
Passenger	Unbelted driver	88	52	23	100	64	100	72
	Belted driver	72	67	31	100	61	75	66
Driver	Average	82	52	31	*	62	*	70
Passenger	Average	80	59	27	100	63	88	69
Average	Unbelted control	81	56	29	45	62	87	69
	Belted control	81	55	29	*	62	*	69
Average	Average	81	56	29	*	62	*	69

* Division by zero -- not defined

Table 4: Passenger Car Front Seat Belt Effectiveness
Model Years 1976 and Later
by Principal Impact Point

Subject	Control	Calculated Effectiveness Roll	Front	Right	Rear	Left	Other	Total
Driver	Unbelted passenger	78	56	60	38	24	52	60
	Belted passenger	75	53	51	45	19	34	57
Passenger	Unbelted driver	72	46	28	28	40	37	50
	Belted driver	76	50	41	19	43	54	54
Driver	Average	76	54	56	41	22	43	58
Passenger	Average	74	48	35	23	41	46	52
Average	Unbelted control	75	51	44	33	32	44	55
	Belted control	75	51	46	32	31	44	55
Average	Average	75	51	45	32	31	44	55

Table 5: Fatalities in the Front Seats of Pickup Trucks
Model Years 1976 and Later
by Accident Year

Accident Year	Safety Belt Used: Driver	Safety Belt Used: Passenger	Number of Deaths: Driver	Number of Deaths: Passenger	Ratio of Injuries: Drivers/Passengers	Ratio of Injuries: Passengers/Drivers
1982	No	No	439	383	1.146	0.872
	No	Yes	2	1	2.000	0.500
	Yes	No	3	3	1.000	1.000
	Yes	Yes	2	3	0.667	1.500
1983	No	No	444	429	1.035	0.966
	No	Yes	1	5	0.200	5.000
	Yes	No	2	7	0.286	3.500
	Yes	Yes	8	6	1.333	0.750
1984	No	No	490	442	1.109	0.902
	No	Yes	7	4	1.750	0.571
	Yes	No	5	10	0.500	2.000
	Yes	Yes	4	3	1.333	0.750
1985	No	No	555	485	1.144	0.874
	No	Yes	21	2	10.500	0.095
	Yes	No	7	20	0.350	2.857
	Yes	Yes	22	16	1.375	0.727
1986	No	No	575	534	1.077	0.929
	No	Yes	32	8	4.000	0.250
	Yes	No	15	37	0.405	2.467
	Yes	Yes	42	41	1.024	0.976
1987	No	No	635	620	1.024	0.976
	No	Yes	40	7	5.714	0.175
	Yes	No	16	58	0.276	3.625
	Yes	Yes	73	74	0.986	1.014
Total	No	No	3,138	2,893	1.085	0.922
	No	Yes	103	27	3.815	0.262
	Yes	No	48	135	0.356	2.813
	Yes	Yes	151	143	1.056	0.947

Table 6: Fatalities in the Front Seats of Passenger Cars
Model Years 1974 and Later
by Accident Year

Accident Year	Safety Belt Used Driver	Safety Belt Used Passenger	Number of Deaths Driver	Number of Deaths Passenger	Ratio of Injuries Drivers/ Passengers	Ratio of Injuries Passengers /Drivers
1982	No	No	2,554	2,567	0.995	1.005
	No	Yes	40	23	1.739	0.575
	Yes	No	29	61	0.475	2.103
	Yes	Yes	72	87	0.828	1.208
1983	No	No	2,401	2,507	0.958	1.044
	No	Yes	53	33	1.606	0.623
	Yes	No	38	69	0.551	1.816
	Yes	Yes	97	116	0.836	1.196
1984	No	No	2,617	2,628	0.996	1.004
	No	Yes	80	56	1.429	0.700
	Yes	No	51	111	0.459	2.176
	Yes	Yes	138	166	0.831	1.203
1985	No	No	2,624	2,590	1.013	0.987
	No	Yes	142	73	1.945	0.514
	Yes	No	81	196	0.413	2.420
	Yes	Yes	319	385	0.829	1.207
1986	No	No	2,737	2,739	0.999	1.001
	No	Yes	226	100	2.260	0.442
	Yes	No	107	305	0.351	2.850
	Yes	Yes	576	677	0.851	1.175
1987	No	No	2,672	2,578	1.036	0.965
	No	Yes	296	130	2.277	0.439
	Yes	No	133	350	0.380	2.632
	Yes	Yes	791	870	0.909	1.100
Total	No	No	15,605	15,609	1.000	1.000
	No	Yes	837	415	2.017	0.496
	Yes	No	439	1,092	0.402	2.487
	Yes	Yes	1,993	2,301	0.866	1.155

Table 7: Pickup Truck Front Seat Belt Effectiveness
Model Years 1976 and Later
by Accident Year

Subject	Control	Calculated Effectiveness						
		1982	1983	1984	1985	1986	1987	Total
Driver	Unbelted passenger	13	72	55	69	62	73	67
	Belted passenger	67	-567	24	87	74	83	72
Passenger	Unbelted driver	43	-417	37	89	73	82	72
	Belted driver	-50	79	63	75	60	72	66
Driver	Average	40	-247	39	78	68	78	70
Passenger	Average	-4	-169	50	82	67	77	69
Average	Unbelted control	28	-173	46	79	68	78	69
	Belted control	8	-244	43	81	67	77	69
Average	Average	18	-208	44	80	68	77	69

Table 8: Passenger Car Front Seat Belt Effectiveness
Model Years 1976 and Later
by Accident Year

Subject	Control	Calculated Effectiveness						
		1982	1983	1984	1985	1986	1987	Total
Driver	Unbelted passenger	52	42	54	59	65	63	60
	Belted passenger	52	48	42	57	62	60	57
Passenger	Unbelted driver	43	40	30	48	56	54	50
	Belted driver	43	34	45	50	59	58	54
Driver	Average	52	45	48	58	64	62	58
Passenger	Average	43	37	38	49	57	56	52
Average	Unbelted control	48	41	42	54	60	59	55
	Belted control	47	41	43	54	61	59	55
Average	Average	47	41	43	54	60	59	55

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