Estimating the Injury-Reducing Benefits of Ejection-Mitigating Glazing

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Executive summary.

The Advanced Glazing Project of NHTSA is an initiative aimed at reducing the number of fatalities and serious injuries in motor vehicle crashes due to ejection. The objective is to determine whether advanced ejection-mitigating glazing in passenger cars, light trucks, and vans would result in substantial benefits in terms of fatality and injury reductions. As part of the project, it was necessary to estimate the numbers of lives saved and serious injuries prevented when ejection is eliminated.

This report describes the statistical analysis performed to obtain such estimates. The analysis utilized state data files maintained by NCSA. It employs the double-pair comparison methodology to compare the injury rates on various severity levels among the ejected and the non-ejected vehicle occupants. It also allows one to calculate fractional reductions in fatalities and incapacitating injuries due to ejection prevention. Since ejection is rare among occupants of motor vehicle using the safety belts, the analysis is restricted to the unrestrained occupants.

The results show dramatically lower fatality rates among non-ejected occupants compared with those ejected ones in the same crash, and substantially lower incapacitating injury rates. The relative risk of fatality of ejected to non-ejected individuals in all ejection crashes is 3.55 for drivers and 3.15 for front seat passengers, which translates into 72 percent and 68 percent reductions in fatalities when ejection is eliminated, respectively. The relative risk of incapacitating injury (given no fatality) is estimated to be 2.39 for drivers and 1.95 for passenger, which means 58 percent and 49 percent reductions in incapacitating injuries, respectively.

An analysis by crash type shows that the greatest benefits of ejection prevention occur in rollover crashes (7.16 relative risk of fatality and 86 percent reduction in fatalities for drivers, and 9.94 relative risk of fatality and 90 percent reduction in fatalities for passengers).

Furthermore, an analysis by vehicle type shows particularly large benefits of ejection prevention in light trucks. For drivers of light trucks in ejection crashes the relative risk of fatality is 5.62 and for passengers it is 4.66 (compared with the non-ejected occupant). The fractional reduction in fatalities is then estimated as 82 percent for drivers and 78.5 percent for passengers when ejection is eliminated from these vehicles.

1. Introduction.

Every year tens of thousands of people are victims of ejection in motor vehicle crashes. A considerable number of these people are seriously injured or killed. Ejection is known to be a factor associated with the most severe consequences in traffic accidents.

In view of this association, the National Highway Traffic Safety Administration (NHTSA) undertook the Advanced Glazing Project, whose objective is to reduce deaths and injuries on our highways through preventing ejection from motor vehicles. The agency has determined that certain encapsulated advanced glazing should be retained in many crashes in which ejection through the currently used glazing is likely. It was then concluded that the presence of such glazing in front side windows should mitigate ejection from the vehicle.

Before recommending whether or not advanced glazing should be installed in the fleet of vehicles, the benefits of ejection prevention have to be assessed. In particular, a cost-benefit analysis of the new technology has to be performed. The present report contributes to this analysis by providing estimates of the relative risk of fatality and injury for ejected occupants of motor vehicles compared to non-ejected occupants and the reduction in fatalities and injuries at different severity levels if ejection were eliminated.

The basic statistical methodology utilized in this study is the double-pair comparison method as described by Evans (1986a), also known as matched-pair analysis. This methodology allows one to obtain comparisons of fatality rates (or serious injury rates) between ejected and non-ejected occupants in crashes of the same severity. Adjustment for crash severity is crucial, since ejections tend to take place in crashes of higher severities. Section 2 of the paper is devoted to an exposition of the double comparison method and some related approaches to the study of fatality and injury distributions among ejected and non-ejected occupants. It also reviews the literature on this topic.

The data analyzed in this study were obtained from the state data files. The database is maintained by the National Center for Statistics and Analysis (NCSA). State data files are records of police accident reports from some 17 states, which are submitted to NCSA annually by the states participating in the program. The files are quite an extensive collection of traffic accident data, since all police-reported accidents are supposed to be represented therein. They can be used for studying both fatal crashes as well as crashes of lesser severities. In Section 3, more detailed information on the data used is presented together with the design of the study. The results of the analysis are presented in Section 4. The appendices contain some state by state results.

2. Double-pair comparison method and related techniques.

The double pair comparison method is a statistical technique designed to study the effect of some characteristic of individuals involved in motor vehicle crashes on the consequences of the crashes to those individuals. To use the method, a collection of data is needed which contains information on the characteristics of interest for all individuals involved in the type of crashes studied as well as the outcomes of the crashes for these individuals. The method was originally applied to study the effect of using or not using a safety belt at the time of a crash (individual characteristic) on whether the crash was fatal to the individual (crash outcome). The original work is Evans (1986a, b), see also Sikora (1986).

The effect of the factor (or characteristic) studied is assessed through an estimate of the ratio of the probability of being subject to the outcome under investigation when the individual in the crash has the characteristic of interest, to the probability of that outcome for individuals without the characteristic. For example, in the studies of the effectiveness of safety belt use, "fatality risk ratio" was estimated, which is the ratio of the probability of fatality for belted drivers in a fatal crash to the fatality probability for unbelted drivers in the same type of crash.

The difficulty in obtaining such estimates is the lack of an obvious measure of exposure to risk for belted and unbelted drivers against which the fatality counts could be compared. The method of double-pair comparison uses the information on passengers of the cars involved in the crashes to produce the required exposure estimates (for the drivers). In the discussion that follows, a passenger is always understood to mean a front seat outboard passenger.

In the context of estimating fatality risk for ejected vs. non-ejected drivers, one can use the data on ejected passengers of cars involved in fatal accidents in the normalizing role (Evans and Frick, 1989). Thus, one looks at all, say , pairs of ejected drivers and ejected passengers in our database and at all, say , pairs of non-ejected drivers and ejected passengers. We then count the number of driver fatalities, say , among the pairs of ejected drivers and ejected passengers, and the number of passenger fatalities, say among the samepairs. Thenis a rough estimate of the probability of fatality of an ejected driver traveling with ejected passenger and is a rough estimate of the probability of fatality of an ejected passenger traveling with an ejected driver. Similarly, if denotes the number of fatalities among the non-ejected drivers traveling with ejected passengers and is the number of fatalities among passengers in the same accidents, then estimates the fatality probability for the non-ejected driver and represents the fatality probability of an ejected passenger.

Consider the fatality ratio , which can be interpreted as the ratio of the probabilities of fatality for ejected driver and ejected passenger. Note that this ratio could be viewed as a measure of relative risk of fatality for drivers vs. passengers in ejection. Now consider the fatality rate , which is interpreted as the ratio of the probabilities of fatality for non-ejected driver and ejected passenger. If the only factor affecting the probability of fatality in the population of motor vehicle occupants under consideration is ejection, then the probability of fatality for non-ejected passengers is the same regardless of whether the driver is ejected of not. Under this assumption (since and both estimate the same quantity), the ratio estimates the ratio of the probabilities of fatality for the ejected driver and the non-ejected driver, which is the relative risk of main interest.

The above argument ignores the fact that fatality probabilities depend on crash severity, and crash severities have different distributions among ejected and non-ejected drivers (and passengers). Evans (1986) addresses this problem (discussing it in terms of belted and unbelted occupants, rather than ejected and non-ejected ones), and presents a mathematical formulation which allows him to argue that even if the distribution of crash severities for belted and unbelted drivers are different, the method can be expected to produce reasonable estimates of the risk ratio . The same arguments could be applied to the problem of ejected vs. non-ejected occupants.

One notices that in using ejected passengers to normalize for exposure to risk, the crashes under consideration become restricted to those involving at least one ejection, and thus the severities of these crashes may not vary too much. In that case, the assumptions on which the double-pair comparison method relies are more likely to be satisfied.

Non-ejected passengers can also be used in the exposure normalizing role. In that case, crashes involving no ejections enter into consideration, and it is more difficult to justify the approach. However, it turns out that both estimates of the relative risk are usually similar.

Furthermore, the roles of drivers and passengers can be reversed, so that drivers can be used in the normalizing role in estimating relative risk of fatality for ejected vs. non-ejected passengers. The formula for the relative risk using ejected drivers as controls is , where , - number of fatalities among ejected passengers traveling with ejected drivers,
 - number of fatalities among ejected drivers traveling with ejected passengers, , - number of fatalities among non-ejected passengers traveling with ejected drivers,
- number of fatalities among ejected drivers traveling with non-ejected passengers.
Finally, the same relative risk can be estimated using non-ejected drivers as controls.

Considering the uncertainties inherent in the method of estimation, in addition to the random nature of the fatality counts, any estimate of the standard error of the relative risk ratio can only be expected to be a tentative assessment. The approach of Evans (1986) is to decompose the standard error into two terms as follows:, where is to account for the imprecision intrinsic to the method itself, and is due to the sampling error. The former is (based on judgment and experience) taken by Evans to be = 0.1 , and the later is calculated, using the method of propagation of errors, under the assumption that the counts , , , , etc., follow the Poisson distribution, which leads to . The estimates of standard errors presented in this paper are obtained using the above method.

Both ejected and non-ejected passengers can be used as controls for risk exposure in estimating the ejected to non-ejected driver fatality risk ratio. It is also possible to obtain three independent estimates of the fatality risk ratio by using fully ejected, partially ejected and non-ejected passengers as controls. Other classes of vehicle occupants (e.g., by age, sex, etc.) serving in exposure normalizing roles can be concocted. The issue of combining these estimates then arises. As suggested by Evans (1986), a weighted average of the estimates is used, with weights inversely proportional to the standard deviations. The weights are applied to the logarithms of the 's, and the sum is then converted to the original scale by exponentiating.

The ratio of the risk of fatality if ejected to the risk of fatality if not ejected, , can be used to estimate the fraction of fatalities that would be prevented by eliminating ejection. The approach (Evans, 1986) is based on the assumption that if ejection were eliminated, then motor vehicle occupants who were originally ejected would be exposed to the same risk of fatality as those occupants who were not ejected in similar crashes. That is, we assume that the ejection-preventing mechanism, such as advanced glazing, will not contribute to fatality risk more than to bring it to the level of risk for occupants not ejected regardless of whether ejection-preventing mechanism is present or not. This can be justified by pointing out that in a crash severe enough to result in an ejection, the occupant not ejected is most likely contained in the vehicle by such elements of the vehicle interior as pillars, dashboard, steering wheel, door frame, etc., which may contribute to the injury as much as the advanced glazing.

Under the above assumptions, a straightforward argument shows that a fraction of ejected fatalities (in a given population of motor vehicle occupants, such as unrestrained drivers of passenger cars) that will be prevented by eliminating ejection is . The standard error of can be calculated, using the method of propagation of errors, as .

The method can equally well be applied to the data on non-fatal accidents to estimate the benefits of advanced glazing in incapacitating injury prevention. The role of fatalities in the above discussion is now played by the incapacitating injuries. One could also look at the non-incapacitating injury prevention benefit of advanced glazing by restricting the analysis to crashes with no fatalities or incapacitating injuries, etc. However, as explained in the next section, because of confounding factors affecting such analysis, the results could not be interpreted as reflecting simply the effect of ejection prevention on injuries at that severity level. Consequently, no such analysis has been undertaken.

3. The state data and the design of the study.

The study utilizes state data files. NCSA currently maintains accident data files from 17 states. The data are submitted to NCSA annually and generally represent records of all police accident reports filed in the submitting states. Since each jurisdiction uses a different police accident report form, with somewhat different data elements coded, the state data files reflect these differences. The essential data element required for the present analysis is the ejection status of vehicle occupants. Out of the 17 states participating in the State Data Program, 14 states report the ejection status, of which 12 (California, Florida, Georgia, Indiana, Louisiana, Maryland, Missouri, Ohio, Pennsylvania, Utah, Virginia, and Washington) include the information on whether the ejection was partial or complete. The data from these 12 states were utilized in the analysis.

The obvious advantage of using the state data is that they are comprehensive. They can be viewed as a census of more serious traffic accidents in the respective states. Although in reality some accidents will not be recorded in the state data, they still contain far more information than any other automated database. They are particularly well suited to study relatively rare types of accidents, such as ejections, where other sources of data will yield insufficient sample sizes. The exception here are the FARS data, which contain information on all fatal crashes in the country. However, FARS data cannot be used to study injury severities associated with ejections, because of their intrinsic bias towards fatal accidents.

There are certain difficulties in working with the state data files. One of them is the above mentioned inconsistencies among different states in terms of data elements present. Furthermore, different states have different reporting thresholds. In all states, injury accidents require filing a police accident report, but in crashes involving only property damage, the minimum damage requiring a report varies. This can conceivably introduce bias in certain types of studies, although ejection accidents are typically quite severe and are likely to be reported in all states. However, in some states information on uninjured occupants is not reported. Thus, the Georgia data exclude information on both the uninjured drivers and passengers, the California data exclude uninjured drivers, and Missouri and Virginia do not report uninjured passengers.

Some of the problems with inconsistencies across states are very likely a result of different practices among the police in different states in coding the same data element. For example, although most states use a similar injury severity scale (based on the KABC0 classification), the interpretation of such categories as ‘incapacitating injury’, ‘nonincapacitating evident injury’, ‘possible injury’ are likely to differ. However, the final results appear relatively consistent and allow reliable conclusions.

Another concern in working with the state data files is the quality of the data -- its accuracy and completeness. There are currently no quality control mechanisms at NCSA used to monitor the data. The data are placed into the automated files as they are provided by the states, with only minor editing to assign common variable names to common (or similar) data elements. While some states implement various consistency checks and other procedures to improve the quality of their data, the effect of these efforts on the state data files at NCSA is not well understood, and the usual tradeoff between quality and quantity has to be expected.

In order to reduce the possibility of biased or otherwise incorrect analysis, the data from each state were analyzed separately. For most types of analyses, the amount of data from individual states was sufficient to obtain meaningful results. The results were then compared among the states to check for possible inconsistencies. In cases when some state’s results appeared questionable because they were substantially different from the results from most other states, further checks were made, and if necessary the state was excluded from the final analysis of the combined data. It turned out that, in addition to Missouri and Virginia, Indiana also does not seem to report uninjured passengers. Furthermore, the distribution of injuries among ejection-accident-involved occupants of motor vehicles in Virginia indicates that the interpretation of the injury scale in that state differs substantially from the other states. Virginia labels its injury severity categories as ‘death’, ‘visible signs of injury’, ‘other visible injury’, ‘complaint’, and ‘not injured’. The percentage of cases in the category ‘visible signs of injury’ is much greater than the percentage of cases in the categories corresponding to ‘incapacitating injury’ in other states, but the percentages in the remaining categories (except ‘death’) are much smaller (see Appendix 1). Because the injury severity reporting in Virginia appears incompatible with the other states, the Virginia data were excluded from the combined data used in calculating injury distributions and reductions in incapacitating injuries due to ejection prevention.

The first step in the analysis was to calculate the injury distributions among the ejected and the non-ejected vehicle occupants. The underlying idea of this analysis was analogous to the double-pair comparison approach. Assuming, as in the double-pair comparison method discussed in Section 2, that the effect of being prevented from ejection by the advanced glazing is (approximately) the same as the effect of being prevented from ejection by other elements of vehicle interior, one can approximate the distribution of injuries among occupants of motor vehicles fitted with advanced glazing by the distribution of injuries among non-ejected occupants of motor vehicles in accidents involving ejection. For example, one can use the injury distribution among non-ejected drivers in crashes in which the passenger was ejected as an estimate of the distribution of injuries among drivers in similar crashes when the advanced glazing is in place.

This distribution is calculated by considering the pairs of non-ejected drivers and ejected passengers as in Section 2, and counting not only the fatal injuries among the drivers, but also the numbers of drivers with incapacitating injuries , nonincapacitating evident injuries , possible injuries , and no injuries . Then the fractions , , , , and represent the desired estimates. Note that this approach is consistent with the double pair comparison method, which relies on the same interpretation of the above fractions. By considering the crashes in which drivers are ejected and passengers are not, an analogous distribution for the passengers can be obtained.

The distribution thus obtained can be used for direct comparison of injury severities among ejected and non-ejected occupants of the same vehicle in a crash. The distributions are also useful for diagnostic purposes -- by calculating the distribution from the data for different states, one can check if results for some states differ significantly from the results for the other states, indicating a potential problem, as discussed above. In the final analysis of combined state data, the following states were included: Florida, Louisiana, Maryland, Ohio, Pennsylvania, Utah, Washington.

More precise comparisons of injury probabilities between ejected and non-ejected motor vehicle occupants are possible using the double-pair comparison method. Applying this methodology, the fractional reduction in fatalities due to ejection prevention (advanced glazing) is calculated. Such calculations have been done in the past (e.g., Evans and Frick, 1989), using the FARS data from the 1980's. The present analysis utilizes the state data for the period 1990-1993. All 12 states' data were used. In spite of the problems with the reporting of uninjured occupants in some states, the reporting of fatalities can be assumed to be accurate. Non-reporting of uninjured occupants might introduce some bias by eliminating the cases where one occupant was killed and another suffered no injury in an ejection crash, but such cases seem quite rare, and the advantage of substantially increasing the sample size by including the additional states outweighs the disadvantage of using possibly slightly inhomogeneous data.

The use of the state data allows one to move a step further than Evans and Frick, and calculate the theoretical reduction in incapacitating injuries due to ejection prevention. Incapacitating injuries (A injuries on the KABC0 scale) are the most common consequence of ejection, followed by nonincapacitating evident injuries (B injuries on KABC0 scale) and fatal injuries. In analyzing reductions in incapacitating injuries associated with ejection prevention, data from all 12 states except Virginia were used. The rationale for including in the analysis the states which do not report certain injured occupants is similar to the one presented above in connection with the fatal injuries analysis. Virginia was excluded because of a very different interpretation of the injury severity scale there.

The approach used restricts the analysis to non-fatal crashes to calculate what proportion of motor vehicle occupants incapacitated in an ejection would have sustained less severe injury (or perhaps no injury) if ejection were eliminated. Restricting the analysis to non-fatal accidents produces results which are properly interpreted in terms of conditional probabilities. For example, the risk ratio is now the ratio of the conditional probability of incapacitating injury given no fatality in an ejection accident to the conditional probability of incapacitating injury given no fatality in an accident without ejection. Similarly, the fractional reduction in incapacitating injuries, , is now the reduction among non-fatally injured.

It would be possible to restrict the analysis to individuals whose injuries were no worse than non-incapacitating (B on the KABC0 scale), and to attempt an evaluation of the ejection prevention benefit to them. However, on that severity level the interpretation of the results becomes problematic, since a large number of those who were not killed or incapacitated because they avoided ejection are counted here. In the analysis, those non-ejected individuals who sustained a major (non-incapacitaing evident) injury but would have suffered a more severe (incapacitating) injury if they had been ejected could not be distinguished from those who would not have suffered a more severe injury. Thus, such analysis might indicate an increase in major (non-incapacitating evident) injuries for non-ejected occupants compared with the ejected occupants not because ejection prevention is associated with more major injuries compared with minor or no injuries, but because the non-ejected occupants are prevented from being more severely injured. Since the above suggested analysis should be restricted to those individuals who are not killed or incapacitated in either type of crash (ejection or non-ejection), it was not feasible to pursue it.

In order to assess more accurately the distribution of injuries among drivers and passengers involved in crashes of sufficient severity to result in ejection who will be prevented from ejection by advanced glazing, a hybrid approach is proposed. Consider individuals presently ejected in traffic accidents. Among them, calculate the proportion of fatally injured individuals who would be saved if ejection were eliminated (using the double-pair comparison method). Those saved are assumed to be now among the incapacitated. The proportion of those incapacitated whose injury would be less severe if not ejected is calculated (again via the double-pair comparison method) and a fraction representing those who benefitted from ejection prevention are counted among those who sustained non-incapacitating evident injury, possible injury, or no injury. Finally, the individuals in the latter three categories are redistributed to conform with the estimated distribution (conditional, given no fatal or incapacitating injury) in those categories based on the preliminary estimates of the distribution of injuries among non-ejected motor vehicle occupants in ejection crashes, as discussed earlier in this section for drivers and passengers.

4. Results.

In analyzing ejection data in traffic accidents, the issue of restraint use has to be considered. It is generally accepted that safety belt use prevents ejection except for very rare cases. The number of cases involving restrained and ejected motor vehicle occupants in the data analyzed in the present study is much smaller than the number of cases involving unrestrained and ejected occupants, although the absolute numbers are not so small. For example, in the 12 states' data between 1990 and 1993 utilized in this study there are 7,643 cases with all required data elements recorded and exactly two occupants, both in front seats, unrestrained, and one ejected (including partial ejections). The analogous number of cases where both occupants were reported restrained is 2,434. Because of the well-known tendency in traffic accident data to overreport restraint use (the so-called lie factor), it is quite clear that many of the cases counted as ejected restrained motor vehicle occupants in fact involve unrestrained individuals. It is not known even approximately what proportion of cases might be affected by overreporting. In view of these uncertainties and because the problem of ejection for restrained motor vehicle occupants is believed to be of quite limited scope, the results presented in this report are restricted to unrestrained individuals. The results based on the data for individuals reported as restrained lead to the same qualitative conclusions, but the distribution of injuries is skewed toward less severe injuries compared with the analogous distribution for unrestrained individuals.

Presented first are distributions of injuries for drivers compared with passengers in crashes where the driver was completely ejected and the passenger was not ejected (based on 1,535 matched pairs in 7 states).

	K	A	B	C	0
Driver	15.37%	36.22%	27.30%	10.68%	10.42%
Passenger	5.34%	21.56%	36.94%	17.39%	18.76%

The analogous results when the driver avoided ejection, but the passenger was completely ejected (based on 2,167 pairs) are presented next.

	K	A	B	C	0
Driver	4.06%	20.12%	30.18%	16.29%	29.35%
Passenger	11.95%	37.24%	31.93%	13.98%	4.89%

Now consider distributions of injuries as above but when the ejection is partial.

Driver partially ejected, passenger not ejected (464 pairs).

	K	A	B	C	0
Driver	25.22%	31.47%	28.01%	11.64%	3.66%
Passenger	8.19%	23.28%	34.48%	20.47%	13.58%

Driver not ejected, passenger partially ejected (583 pairs).

	K	A	B	C	0

Driver	6.17%	24.36%	33.28%	15.09%	21.10%
Passenger	17.32%	37.05%	32.76%	8.75%	4.12%

It is also quite relevant to look at the distribution of injuries among all ejected (completely or partially) drivers or passengers and to compare it with the injury distribution for the non-ejected occupant in the same crash. The results are as follows.

Driver ejected, passenger not ejected (1,999 pairs).

	K	A	B	C	0
Driver	17.66%	35.12%	27.46%	10.91%	8.85%
Passenger	6.00%	21.96%	36.37%	18.11%	17.56%

Driver not ejected, passenger ejected (2,750 pairs).

	K	A	B	C	0
Driver	4.51%	21.02%	30.84%	16.04%	27.60%
Passenger	13.09%	37.20%	32.11%	12.87%	4.73%

As mentioned in Section 3, each state's data has its own characteristics. The above results were obtained by combining injury counts in the five categories across the 7 states, which amounts to averaging across states. The results for individual states are presented in Appendix 1.

A more detailed analysis was performed to estimate the fractional reduction in fatalities and fractional reduction in incapacitating injuries among motor vehicle occupants who were not ejected compared to those ejected. These estimates were obtained using the double-pair comparison method described in Section 2. Thus, the analysis adjusts for crash severity as well as the difference in fatality or incapacitating injury risk between drivers and passengers. Two estimates are presented: first, the relative risk of fatality (or incapacitating injury) for ejected compared with non-ejected drivers (or passengers), which represents an estimate of the ratio of the probability of fatality (or incapacitating injury) for ejected motor vehicle occupants to the same probability for the non-ejected occupants; and second, the fractional reduction in fatalities (or incapacitating injuries) due to ejection prevention. This is calculated as , where is the relative risk. Standard errors, calculated according to the methods of Evans (as discussed in Section 2) are also given.

The results presented were obtained by combining the data from 12 states as mentioned in Section 3. The results for individual states are presented in Appendix 2. There appeared to be no need to eliminate any of the state data since the results are quite consistent from state to state. Presumably this reflects the fact that the recording of fatalities and incapacitating injuries is more accurate and uniform than the recording of the less severe injuries. The numbers in parentheses represent error estimates.

The first three tables show the total ejection prevention benefits on fatalities for all types of crashes and all vehicles.

Complete Ejections

	Relative Risk of Fatality	Fractional Reduction in Fatalities
Driver	3.46 (0.94)	71.06% (7.85%)
Passenger	3.10 (0.84)	67.76% (8.71%)

Partial Ejections

	Relative Risk of Fatality	Fractional Reduction in Fatalities
Driver	3.59 (0.85)	72.15% (6.57%)
Passenger	3.15 (0.74)	68.27% (7.49%)

All Ejections

	Relative Risk of Fatality	Fractional Reduction in Fatalities
Driver	3.55 (0.83)	71.85% (6.56%)
Passenger	3.15 (0.73)	68.23% (7.40%)

The next three tables show the analogous results when incapacitating injuries (excluding fatalities) are considered.

Complete Ejections

	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	2.05 (0.52)	51.20% (12.40%)
Passenger	1.80 (0.46)	44.29% (14.23%)

Partial Ejections

	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	2.47 (0.57)	59.54% (9.27%)

Partial Ejections

Passenger	2.00 (0.46)	50.05% (11.45%)

All Ejections

	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	2.38 (0.54)	58.11% (9.55%)
Passenger	1.95 (0.44)	48.64% (11.72%)

It is of interest to consider the benefits of ejection prevention for light trucks and for passenger cars separately. Light trucks are known to be more likely to be involved in rollovers, and rollovers are often associated with ejection. In general, ejections are more frequent from light trucks than from passenger cars. First presented are the results for light trucks.

Complete Ejections - Light Truck

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	4.13 (1.48)	75.80% (8.65%)	3.14 (1.02)	68.17% (10.36%)
Passenger	3.94 (1.46)	74.60% (9.42%)	1.89 (0.62)	47.04% (17.27%)

Partial Ejections - Light Truck

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	6.42 (1.83)	84.43% (4.44%)	2.75 (0.66)	63.58% (8.82%)
Passenger	5.36 (1.53)	81.35% (5.32%)	2.23 (0.54)	55.06% (10.95%)

All Ejections - Light Truck

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries

All Ejections - Light Truck

Driver	5.62 (1.49)	82.19% (4.73%)	2.76 (0.66)	63.76% (8.65%)
Passenger	4.66 (1.24)	78.55% (5.70%)	2.22 (0.53)	54.87% (10.82%)

The results for passenger cars are as follows.

Complete Ejections -Passenger Car

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	3.25 (0.94)	69.19% (8.92%)	1.95 (0.52)	48.71% (13.62%)
Passenger	3.06 (0.87)	67.29% (9.35%)	1.81 (0.48)	44.69% (14.68%)

Partial Ejections - Pasenger Car

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	2.84 (0.68)	64.74% (8.44%)	2.85 (0.69)	64.97% (8.42%)
Passenger	2.54 (0.61)	60.56% (9.44%)	2.54 (0.61)	60.70% (9.45%)

All Ejections - Passenger Car

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	2.94 (0.69)	66.06% (8.00%)	2.37 (0.55)	57.83% (9.70%)
Passenger	2.66 (0.63)	62.46% (8.85%)	1.88 (0.43)	46.79% (12.26%)

In evaluating the benefits of ejection-preventing advanced glazing, it is also of interest to estimate the reduction in fatalities and incapacitating injuries in crashes of various types. Here the crashes are classified by the direction of the main impact as front end, rear end, left side, right side, and rollover crashes. The crash type, together with crash severity, determine whether advanced glazing will remain in the vehicle to prevent ejections of the vehicle occupants. The crash type also determines the most likely ejection route. Detailed information about ejection path and whether advanced glazing would have remained in specific crashes is not available from the state data, but it is possible to estimate the relative risk of fatality and incapacitating injury in different types of crashes and to estimate the fatality and incapacitating injury reduction due to ejection prevention in a given crash type (assuming all advanced glazing would remain in place). These results are presented next.

Front impact crashes.

Complete Ejections - Front Impact

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	3.96 (1.46)	74.72% (9.30%)	2.00 (0.63)	49.88% (15.84%)
Passenger	3.29 (1.18)	69.64% (10.85%)	1.74 (0.56)	42.49% (18.40%)

Partial Ejections - Front Impact

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	3.41 (0.94)	70.64% (8.06%)	2.40 (0.59)	58.27% (10.32%)
Passenger	3.08 (0.84)	67.54% (8.89%)	1.78 (0.44)	43.87% (13.92%)

All Ejections - Front Impact

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	3.55 (0.93)	71.85% (7.33%)	2.34 (0.56)	57.18% (10.33%)
Passenger	3.17 (0.82)	68.46% (8.21%)	1.73 (0.42)	42.08% (14.01%)

There was not enough data to carry out the estimation procedure for completely ejected occupants of motor vehicles in rear impact crashes (ejections in such crashes are relatively rare). Consequently, the results are only presented for all ejections in rear end crashes (partial and complete combined), where the sample size becomes large enough to give reasonable stable results.

All Ejections - Rear Impact

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	3.31 (1.69)	69.75% (15.42%)	1.94 (0.69)	48.39% (18.25%)
Passenger	3.08 (1.57)	67.52% (16.61%)	1.56 (0.55)	35.69% (22.78%)

Left side impact crashes.

Complete Ejections - Left Side Impact

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	1.60 (0.82)	37.46% (32.24%)	2.16 (1.02)	53.78% (21.73%)
Passenger	3.15 (1.64)	68.22% (16.52%)	1.61 (0.83)	37.74% (32.09%)

Partial Ejections - Left Side Impact

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	2.34 (0.88)	57.35% (16.07%)	2.11 (0.81)	52.55% (18.12%)
Passenger	3.58 (1.32)	72.03% (10.29%)	3.60 (1.35)	72.24% (10.37%)

All Ejections - Left Side Impact

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	2.10 (0.70)	52.48% (15.91%)	1.80 (0.51)	44.59% (15.54%)
Passenger	3.46 (1.15)	71.06% (9.60%)	2.23 (0.64)	55.18% (12.88%)

Right side impact crashes.

Complete Ejections - Right Side Impact

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	4.84 (2.23)	79.33% (9.54%)	1.97 (0.88)	49.16% (22.78%)
Passenger	1.81 (0.91)	44.70% (27.81%)	1.27 (0.56)	21.30% (34.38%)

Partial Ejections - Right Side Impact

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	3.21 (1.05)	68.85% (10.23%)	3.37 (0.99)	70.32% (8.72%)
Passenger	1.67 (0.55)	40.26% (19.64%)	1.83 (0.53)	45.21% (15.96%)

All Ejections - Right Side Impact

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	3.54 (1.07)	71.73% (8.55%)	3.06 (0.85)	67.37% (9.07%)
Passenger	1.80 (0.54)	44.29% (16.90%)	1.69 (0.47)	40.90% (16.41%)

Rollover crashes.

Complete Ejections - Rollover

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	7.75 (4.13)	87.09% (6.87%)	2.03 (0.78)	50.75% (18.87%)

Complete Ejections - Rollover

Passenger	9.70 (5.38)	89.70% (5.72%)	2.17 (0.86)	53.96% (18.27%)

Partial Ejections - Rollover

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	6.94 (2.28)	85.60% (4.73%)	3.21 (0.81)	68.87% (7.90%)
Passenger	10.09 (3.36)	90.09% (3.30%)	2.79 (0.71)	64.22% (9.13%)

All Ejections - Rollover

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	7.16 (2.24)	86.03% (4.37%)	3.08 (0.77)	67.52% (8.10%)
Passenger	9.94 (3.14)	89.94% (3.17%)	2.63 (0.67)	62.60% (9.38%)

References.

Evans, L. Double pair comparison -- a new method to determine how occupant characteristics affect fatality risk in traffic crashes. Accid. Anal. Prev. 17, 217-227, 1986a.

Evans, L. The effectiveness of safety belts in preventing fatalities. Accid. Anal. Prev. 17, 229-241, 1986b.

Evans, L. and Frick, M. Potential fatality reductions through eliminating occupant ejection from cars. Accid. Anal. Prev. 21, 169-182, 1989.

Sikora, J. J. Relative risk of death for ejected occupants in fatal traffic accidents. NHTSA Technical Report No. DOT HS-807-096. Washington, DC, November 1986.

Appendix 1. Distribution of injuries by state.

Presented below are distributions of injuries among drivers and passengers in accidents involving exactly two unrestrained front seat occupants, one of whom was ejected (completely or partially) as calculated from the state data files, typically covering the period 1990 to 1993 for each of the 12 states used in the present study. In the case of several states the distributions were calculated for different years separately (due to computer resources constraints). Since the main purpose for presenting these results is diagnostics, the results are presented as originally calculated.

Injury severity categories are labeled in accordance with the KABC0 scale (K - fatality, A - incapacitating injury, B - nonincapacitating evident injury, C - possible injury, 0 - no injury). The injury scale categories in individual states are reproduced below.

CA - killed, severe injury, other visible injury, complaint of pain, not injured
FL - fatal injury, incapacitating injury, non-incapacitating injury, possible injury, no injury
GA - killed, serious, visible, complaint, not stated
IN - (no injury scale comparable to KABC0)
LA - fatal, critical non-fatal, serious non-fatal, severe, moderate, minor, no injury
MD - fatal, incapacitating injury, nonincapacitating injury, possible injury, no injury
MO - fatal, disabling, evident not disabling, probable not apparent, none apparent
OH - fatal injury, serious visible incapacitating injury, minor visible injury, no visible claimed injury, no injury
PA - death, major injury (incapacitating), moderate injury (nonincapacitating), minor injury (probable), no injury
UT - fatal, broken bones and bleeding wounds, bruises and abrasions, possible injury, no injury
VA - died/dead, visible signs of injury, other visible injury, no visible injury but complaint, not injured
WA - dead, disabling injury, non-disabling injury, possible injury, no injury

With minor exceptions, these injury scales conform to the KABC0 classification and in presenting the results below injury categories were uniformly labeled using the symbols K, A, B, C, 0. An asterisk indicates a state excluded from the calculation of combined state data injury distribution.

The first group of results is for pairs of ejected drivers with non-ejected passengers.

California 1990-93 (587 cases) *

	K	A	B	C	0

California 1990-93 (587 cases) *

Driver	24.36%	30.49%	36.12%	9.03%	0%
Passenger	4.60%	15.50%	44.97%	22.32%	12.61%

Florida 1990-91 (361 cases)

	K	A	B	C	0
Driver	15.79%	27.98%	26.04%	10.80%	19.39%
Passenger	4.71%	21.05%	32.13%	15.24%	26.87%

Florida 1992-93 (342 cases)

	K	A	B	C	0
Driver	12.28%	33.63%	21.35%	11.40%	21.35%
Passenger	2.92%	20.47%	35.09%	14.91%	26.61%

Georgia 1990-93 (261 cases) *

	K	A	B	C	0
Driver	18.01%	32.95%	41.00%	8.05%	0%
Passenger	5.75%	17.24%	59.39%	17.62%	0%

Indiana 1990-93 (191 cases) *

	K	A	B	C	0
Driver	13.09%	38.74%	26.70%	17.28%	4.19%
Passenger	2.09%	32.46%	33.51%	31.94%	0%

Louisiana 1989-90 (102 cases)

	K	A	B	C	0
Driver	17.65%	23.53%	30.39%	26.47%	1.96%
Passenger	7.84%	6.86%	25.49%	44.12%	15.69%

Maryland 1989-92 (144 cases)

	K	A	B	C	0
Driver	18.75%	50.00%	13.19%	9.72%	8.33%
Passenger	4.17%	39.58%	27.78%	15.97%	12.50%

Missouri 1989-92 (312 cases) *

	K	A	B	C	0
Driver	19.23%	43.59%	28.21%	7.69%	1.28%
Passenger	2.56%	26.61%	53.85%	16.67%	0.32%

Ohio 1989 (119 cases)

	K	A	B	C	0
Driver	21.01%	34.45%	38.66%	5.04%	0.84%
Passenger	6.72%	22.69%	52.94%	8.40%	9.24%

Ohio 1990 (85 cases)

	K	A	B	C	0
Driver	14.12%	42.35%	36.47%	7.06%	0%
Passenger	7.06%	28.24%	45.88%	11.76%	7.06%

Ohio 1991 (82 cases)

	K	A	B	C	0
Driver	17.07%	36.59%	36.59%	7.32%	2.44%
Passenger	9.76%	19.51%	46.34%	13.41%	10.98%

Ohio 1992 (100 cases)

	K	A	B	C	0
Driver	25.00%	31.00%	37.00%	4.00%	3.00%
Passenger	5.00%	27.00%	50.00%	1.00%	8.00%

Ohio 1993 (84 cases)

	K	A	B	C	0
Driver	16.67%	34.52%	40.48%	5.95%	2.38%
Passenger	5.95%	26.19%	51.19%	8.33%	8.33%

Pennsylvania 1989-91 (188 cases)

	K	A	B	C	0
Driver	21.28%	30.32%	30.32%	17.55%	0.53%
Passenger	10.64%	12.77%	30.32%	32.45%	13.83%

Pennsylvania 1992-93 (85 cases)

	K	A	B	C	0
Driver	21.18%	29.41%	27.06%	21.18%	1.18%
Passenger	11.76%	18.82%	16.47%	36.47%	16.47%

Utah 1989-92 (133 cases)

	K	A	B	C	0
Driver	17.29%	53.38%	21.05%	6.77%	1.50%
Passenger	3.01%	36.84%	36.09%	11.28%	12.78%

Virginia 1990-93 (222 cases) *

	K	A	B	C	0
Driver	21.62%	69.40%	7.21%	1.35%	0.45%
Passenger	4.95%	71.17%	13.51%	10.36%	0%

Washington 1990-93 (174 cases)

	K	A	B	C	0
Driver	21.84%	40.23%	26.44%	6.90%	4.60%
Passenger	7.47%	13.79%	41.95%	18.97%	17.82%

The distributions of injuries for non-ejected drivers and ejected passengers by state are as follows.

California 1990-93 (569 cases) *

	K	A	B	C	0
Driver	4.04%	16.52%	54.31%	22.14%	2.99%
Passenger	20.21%	33.22%	35.50%	10.54%	0.53%

Florida 1990-91 (464 cases)

	K	A	B	C	0
Driver	2.16%	16.59%	29.74%	15.95%	35.56%
Passenger	9.27%	34.27%	36.21%	13.36%	6.90%

Florida 1992-93 (433 cases)

	K	A	B	C	0
Driver	4.16%	22.86%	26.10%	14.55%	32.33%
Passenger	12.70%	35.57%	31.41%	11.78%	8.55%

Georgia 1990-93 (342 cases) *

	K	A	B	C	0
Driver	5.56%	17.25%	61.40%	15.79%	0%
Passenger	18.13%	27.49%	48.54%	5.85%	0%

Indiana 1990-93 (261 cases) *

	K	A	B	C	0
Driver	3.36%	19.92%	29.50%	18.39%	26.82%
Passenger	10.34%	40.23%	30.27%	19.16%	0%

Louisiana 1989-90 (133 cases)

	K	A	B	C	0
Driver	4.51%	11.28%	22.56%	35.34%	26.32%
Passenger	15.79%	26.32%	22.56%	26.32%	9.02%

Maryland 1989-92 (171 cases)

	K	A	B	C	0
Driver	2.92%	35.67%	15.20%	12.28%	33.92%
Passenger	12.28%	47.95%	18.13%	12.28%	9.36%

Missouri 1989-92 (510 cases) *

	K	A	B	C	0
Driver	4.12%	19.41%	41.96%	8.82%	25.69%
Passenger	10.78%	46.08%	37.65%	5.49%	0%

Ohio 1989 (183 cases)

	K	A	B	C	0
Driver	5.46%	19.13%	42.08%	12.02%	21.31%
Passenger	10.38%	38.80%	40.98%	5.46%	4.37%

Ohio 1990 (148 cases)

	K	A	B	C	0
Driver	4.73%	23.65%	32.43%	10.81%	28.38%
Passenger	8.11%	39.19%	44.59%	6.08%	2.03%

Ohio 1991 (144 cases)

	K	A	B	C	0
Driver	8.33%	25.00%	36.11%	5.55%	25.00%
Passenger	15.97%	39.58%	34.72%	7.64%	2.08%

Ohio 1992 (124 cases)

	K	A	B	C	0
Driver	3.23%	22.58%	45.16%	8.06%	20.97%
Passenger	12.10%	40.32%	40.32%	4.84%	2.42%

Ohio 1993 (119 cases)

	K	A	B	C	0
Driver	5.88%	26.89%	42.86%	7.56%	16.81%
Passenger	18.49%	32.77%	39.50%	5.04%	4.20%

Pennsylvania 1989-91 (311 cases)

	K	A	B	C	0
Driver	6.11%	13.50%	26.05%	28.62%	25.72%
Passenger	16.72%	29.58%	29.58%	24.12%	0%

Pennsylvania 1992-93 (136 cases)

	K	A	B	C	0
Driver	5.15%	15.44%	23.53%	31.62%	24.26%
Passenger	17.65%	34.56%	24.26%	23.53%	0%

Utah 1989-92 (159 cases)

	K	A	B	C	0
Driver	3.78%	35.85%	29.56%	8.81%	22.01%
Passenger	13.21%	61.01%	19.50%	4.40%	1.89%

Virginia 1990-93 (274 cases) *

	K	A	B	C	0
Driver	6.93%	70.44%	13.14%	9.49%	0%
Passenger	15.33%	74.45%	4.38%	5.84%	0%

Washington 1990-93 (225 cases)

	K	A	B	C	0
Driver	5.78%	17.78%	43.11%	11.11%	22.22%
Passenger	14.22%	36.44%	32.89%	12.89%	3.56%

One notices that while the percentages of fatalities and more serious injuries are fairly consistent across all states, the percentages in less severe injury categories vary more widely. In particular, in some states zero percentages are observed in the ‘no injury category’. These indicate possible non-reporting of uninjured occupants (particularly passengers). It should be noticed that in some states which purport not to include uninjured occupants in their data files, non-zero entries are nonetheless observed in the 0 category. This is probably due to the recording of this information on some police accident reports, even though it may not be required in a given case. Of course, such data are not reliable.

Appendix 2. Relative risk of fatality or incapacitating injury and fractional reduction in fatalities or incapacitating injuries by state.

Only the results for all ejections (partial and complete) are presented by state. The breakdown by ejection type, vehicle type, or crash type is not shown. The main purpose of presenting the results is to show that the numbers are quite consistent across states, indicating that the data is of adequate quality for the purposes of this analysis.

Virginia data were not used in calculating the fractional reduction in incapacitating injuries in the analysis of combined state data.

The results are presented in the same format as in Section 3.

California 1990-93

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	5.14 (1.44)	80.55% (5.46%)	2.95 (0.75)	66.06% (8.58%)
Passenger	5.13 (1.44)	80.49% (5.47%)	2.64 (0.67)	61.15% (9.62%)

Florida 1990-91

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	4.25 (1.40)	76.52% (7.72%)	2.38 (0.63)	57.93% (11.16%)
Passenger	3.21 (1.06)	68.83% (10.33%)	1.99 (0.54)	49.75% (13.64%)

Florida 1992-93

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	4.04 (1.37)	75.25% (8.41%)	2.11 (0.57)	52.64% (12.82%)
Passenger	3.08 (1.03)	67.54% (10.86%)	1.82 (0.49)	45.11% (14.80%)

Georgia 1990-93

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	3.40 (1.07)	70.57% (9.26%)	2.19 (0.61)	54.36% (12.71%)
Passenger	3.04 (0.95)	67.06% (10.32%)	1.88 (0.52)	46.92% (14.67%)

Indiana 1990-93

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	3.12 (1.24)	67.94% (12.78%)	2.07 (0.60)	51.73% (13.89%)
Passenger	2.86 (1.11)	65.06% (13.53%)	1.62 (0.47)	38.17% (17.84%)

Louisiana 1989-90

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	2.70 (1.13)	62.99% (15.54%)	5.26 (2.23)	81.01% (8.04%)
Passenger	2.82 (1.19)	64.55% (14.99%)	3.54 (1.46)	71.72% (11.68%)

Maryland 1989-92

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	4.85 (2.10)	79.39% (8.90%)	1.62 (0.48)	38.33% (18.21%)
Passenger	4.00 (1.74)	75.02% (10.88%)	1.34 (0.40)	25.11% (22.37%)

Missouri 1989-93

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	4.67 (1.54)	78.57% (7.09%)	2.67 (0.69)	62.53% (9.64%)
Passenger	3.67 (1.20)	72.75% (8.93%)	1.96 (0.51)	48.93% (13.31%)

Ohio 1989

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	1.92 (0.76)	47.70% (20.75%)	2.29 (0.74)	56.35% (14.07%)
Passenger	3.07 (1.21)	67.43% (12.88%)	1.98 (0.64)	49.43% (16.44%)

Ohio 1990

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	2.12 (0.96)	52.81% (21.37%)	1.90 (0.65)	47.36% (17.89%)
Passenger	1.63 (0.73)	38.60% (27.64%)	1.71 (0.60)	41.55% (20.40%)

Ohio 1991

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	2.03 (0.83)	50.86% (20.01%)	2.10 (0.73)	52.43% (16.61%)
Passenger	1.64 (0.66)	39.16% (24.41%)	1.95 (0.66)	48.79% (17.29%)

Ohio 1992

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	5.16 (2.43)	80.62% (9.12%)	1.90 (0.63)	47.54% (17.28%)
Passenger	3.71 (1.77)	73.06% (12.85%)	1.72 (0.60)	41.71% (20.23%)

Ohio 1993

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	3.04 (1.37)	67.05% (14.87%)	2.07 (0.73)	51.77% (16.96%)
Passenger	3.13 (1.39)	68.05% (14.15%)	1.44 (0.49)	30.39% (23.95%)

Pennsylvania 1989-90

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	2.60 (0.93)	61.56% (13.79%)	3.22 (1.08)	68.94% (10.43%)
Passenger	2.16 (0.76)	71.06% (9.60%)	2.58 (0.85)	61.21% (12.86%)

Pennsylvania 1992-93

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	2.11 (0.84)	52.60% (18.92%)	2.92 (1.06)	65.81% (12.34%)
Passenger	2.80 (1.13)	64.34% (14.33%)	2.07 (0.73)	51.71% (17.07%)

Utah 1990-93

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	5.02 (2.29)	80.09% (9.10%)	2.18 (0.63)	54.04% (13.38%)
Passenger	3.89 (1.79)	74.30% (11.82%)	1.76 (0.52)	43.08% (16.91%)

Virginia 1990-93

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	3.46 (1.16)	71.09% (9.71%)	1.21 (0.31)	17.37% (21.25%)
Passenger	2.70 (0.90)	62.95% (12.33%)	1.16 (0.30)	14.04% (22.50%)

Washington 1990-93

	Relative Risk of Fatality	Fractional Reduction in Fatalities	Relative Risk of Incapacitating Injury	Fractional Reduction in Incapacitating Injuries
Driver	2.91 (1.02)	65.62% (12.11%)	3.34 (1.02)	70.06% (9.18%)
Passenger	2.49 (0.88)	59.76% (14.19%)	2.83 (0.87)	64.61% (10.84%)