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Fatality Reduction by Air Bags

Analyses of Accident Data through Early 1996

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16. Abstract

The fatality risk of front-seat occupants of passenger cars and light trucks equipped with air bags is compared to the corresponding risk in similar vehicles without air bags, based on statistical analyses of Fatal Accident Reporting System (FARS) data from 1986 through early 1996. The principal conclusion is that driver air bags save lives. The fatality reduction benefit of air bags for all drivers is an estimated 11 percent; this percentage is essentially unchanged from 1992 and 1994 analyses by NHTSA staff. New, positive findings are that driver air bags save lives in light trucks and in small cars, that passenger air bags save lives of right-front passengers age 13 or older, and that driver air bags provide a significant supplemental life-saving benefit for the driver who buckles up (as well as saving lives of unbelted drivers). On the other hand, preliminary analyses of limited accident data show a higher fatality risk for child passengers age 0-12 in cars with current dual air bags than in cars without a passenger air bag. Also, current air bags may have diminished, or even negligible benefits for drivers age 70 or older, and they do not have a statistically significant effect for drivers of any age group in oblique-frontal crashes.

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EXECUTIVE SUMMARY

Driver air bags first appeared as standard equipment on a few 1985 make-models. When automatic occupant protection was phased into passenger cars during model years 1987-90, the National Highway Traffic Safety Administration (NHTSA) did not mandate air bags, but allowed any system meeting the agency's test requirements, such as air bags or automatic belts. Nevertheless, the agency explained that the combination of a 3-point safety belt, correctly buckled, plus an air bag provides the best occupant protection. The public agreed, expressing an almost immediate preference for air bags over automatic belts. In 1990, more than a million cars with driver air bags were sold. By 1993, the majority of new cars had driver air bags, and by 1994, dual air bags. By 1995, the majority of new light trucks had driver or dual air bags. All new cars will be required to have dual air bags and manual 3-point belts in model year 1998, and all new light trucks in 1999.

Pursuant to Executive Order 12286, NHTSA evaluates the actual safety benefits of its existing regulations, based on statistical analyses of accident data, to see if the standards are indeed effective and meeting their regulatory goals. The fatality-reducing effectiveness of air bags is a matter of continuing interest to NHTSA. Statistical analyses of the available accident data were published in 1992 and 1994. The 1992 analysis found that air bags for drivers of passenger cars were reducing fatality risk by 11 percent; the 1994 analysis found a 10 percent reduction. NHTSA now has records of 7933 driver fatalities in cars equipped with air bags, as compared to 777 at the time of the 1992 study and 2069 in 1994. A more detailed analysis of fatality reduction can be performed for car drivers. Also, since there have been 855 driver fatalities in light trucks and vans equipped with air bags and 782 right-front passenger fatalities in cars equipped with dual air bags, it is possible to take a first look at the effect of air bags for drivers of light trucks and for car passengers.

Analyses are based on Fatal Accident Reporting System (FARS) data from 1986 to early 1996. FARS is a census of fatal crashes in the United States. Two statistical methods are used to assess fatality reduction. The first hinges on the fact that millions of cars and light trucks have an air bag for the driver, but not the right-front passenger; the ratio of driver to passenger fatalities in these vehicles is compared to corresponding ratios in similar vehicles with air bags at neither position, or at both. The second method hinges on the fact that air bags are primarily designed to deploy and have potential benefits in frontal crashes; the ratio of frontal to nonfrontal fatalities in vehicles equipped with air bags is compared to the corresponding ratio in similar vehicles without air bags. Results by the two methods are averaged. Fatality reductions are described as "statistically significant" if one or (in most cases) both methods show a significant reduction. The report describes how statistical significance is tested and how confidence bounds are calculated.

The primary objective is to find the overall, average fatality reduction by air bags for the entire population of occupants, including those who use their safety belts and those who do not. However, to the extent that the data allow, it is also important to estimate separately the effect of an air bag for an unbelted occupant, and the supplemental fatality reduction by air bags for an occupant who wears safety belts.

The principal conclusion of the study is that driver air bags save lives. The fatality reduction benefit of air bags for all drivers is an estimated 11 percent; this percentage is essentially unchanged from the 1992 and 1994 analyses. New, positive findings are that driver air bags save lives in light trucks and in small cars, that passenger air bags save lives of right-front passengers age 13 or older, and that driver air bags provide a significant supplemental life-saving benefit for the driver who buckles up (as well as saving lives of unbelted drivers).

On the other hand, in-depth crash investigations have revealed 22 cases, as of July 1996, where children may have sustained fatal lesions from interactions with passenger air bags. The accident data now in the FARS are insufficient to determine a specific numerical value for the effect of air bags for child passengers. However, to the extent that preliminary analyses show a higher fatality risk for child passengers age 0-12 in cars with dual air bags than in cars without a passenger air bag, the current data sustain the concerns raised by the in-depth investigations. Statistical analyses also suggest two other possible problems with current air bags: they may have diminished, or even negligible benefits for drivers age 70 or older, and they do not have a statistically significant effect for drivers of any age group in oblique-frontal crashes.

The main findings and conclusions of the evaluation are the following:

AIR BAGS SAVE LIVES

- If no passenger cars or light trucks had been equipped with driver or passenger air bags, it is estimated that a total of 1136 additional fatalities would have occurred during 1986-95 (approximate confidence bounds: 692 to 1622).

OVERALL FATALITY REDUCTION - DRIVER AIR BAGS - PASSENGER CARS

- Air bags reduce the overall fatality risk of car drivers by a statistically significant 11 percent (confidence bounds: 7 to 15 percent). In other words, a fleet of cars equipped with air bags will have 11 percent fewer driver fatalities, total, than the same cars would have had if they did not have air bags.

- Driver air bag effectiveness is holding steady. The estimate of fatality reduction is essentially unchanged from the 1992 and 1994 analyses by NHTSA staff.

PURE FRONTALS VS. PARTIAL FRONTALS - DRIVER AIR BAGS - PASSENGER CARS

- Driver air bags for passenger cars are effective in purely frontal impacts (12:00 damage and no subsequent rollover). The estimated fatality reduction is a statistically significant 30½ percent (confidence bounds: 24 to 37 percent).

- Air bags are significantly less effective for car drivers in partially frontal impacts (11, 1, 10 or 2:00 damage; or 12:00 damage with subsequent rollover) than in purely frontal impacts.

FATALITY REDUCTION - DRIVER AIR BAGS - LIGHT TRUCKS AND VANS

- Driver air bags in light trucks - pickup trucks, vans and sport utility vehicles - are effective in purely frontal crashes. The fatality reduction is a statistically significant 27 percent (confidence bounds: 14 to 40 percent).

- Air bags reduce the overall fatality risk of light truck drivers by a statistically significant 10 percent.

- The preliminary conclusion is that driver air bags are about as effective in light trucks and vans as they are in cars. However, many of the vehicles that first got air bags were minivans. The conclusion will need to be reassessed as more data become available, especially for pickup trucks and sport utility vehicles.

FATALITY REDUCTION - PASSENGER AIR BAGS - CAR PASSENGERS AGE 13 OR OLDER

- Passenger air bags in cars are effective for right-front occupants **age 13 or older** in purely frontal crashes. The fatality reduction is a statistically significant 27 percent (confidence bounds: 9 to 45 percent).

- Air bags reduce the overall fatality risk of car passengers age 13 or older by a statistically significant 13½ percent.

- The preliminary conclusion is that air bags are about as effective for passengers **age 13 or older** as for drivers. If so, it is estimated that an additional 88 right front passengers age 13 or older would have died during 1986-95 if no passenger cars or light trucks had been equipped with passenger air bags.

PASSENGER AIR BAGS AND CHILDREN AGE 0-12

- The agency's Special Crash Investigation teams, as of July 1996, have identified 22 fatalities of child passengers in low-severity frontal crashes of vehicles equipped with dual air bags (14 before the end of 1995 and 8 during January-July 1996). Infants in rear-facing safety seats, and unrestrained or improperly restrained children who were out of position prior to the main impact, appear to have contacted the air bag during the forceful early phase of its deployment.

- Preliminary analyses of the limited available accident data show increases in fatality risk with passenger air bags for right-front passengers age 0-12 in frontal crashes. The observed effects vary widely, depending on the analysis method, and they are only statistically significant in some of the analyses. In other words, although a specific numerical value on the effect of air bags cannot yet be determined, the results are consistent with the conclusion, from special crash investigations, that child passengers are experiencing problems with air bags.

- The Department of Transportation has formed a coalition with manufacturers, insurance companies and other organizations to prevent injuries and fatalities which may be *inadvertently* caused by air bags, especially to children. The May 21, 1996 press release announcing the coalition offers the following safety guidelines for child passengers:

  "Infants in rear-facing child safety seats should <u>never</u> be placed in the front seat if the vehicle has a passenger-side air bag. The safest place for children of all ages is the back seat. If riding in the back seat is not an option, toddlers and older children may ride in the front seat of a vehicle with a passenger-side air bag, but only if buckled up properly and with the seat moved as far back as possible."

- On August 1, 1996, NHTSA proposed changes to the air bag requirement with a goal of reducing the risks of air bags to children:

  - The motor vehicle industry is encouraged to begin installing, at the earliest possible date, a 'smart' passenger air bag system that will detect when a child is present and automatically deactivate the air bag or enable it to deploy safely.

  - One kind of 'smart' system that appears to be available now is a weight sensor in the seat that prevents the air bag from deploying when a child is in the seat.

  - Manufacturers who do not provide a qualifying 'smart' system would be required to have new and more prominent air bag warning labels inside the vehicle. They would also be permitted to install cutoff switches so parents can deactivate the passenger-side air bag when a child is seated in front of it.

  - The press release announcing these proposals emphasized that parents can generally **eliminate the air bag risk immediately by insisting that their children ride buckled up in the rear seat**.

- During 1986-95, as stated above, 14 child passengers apparently received fatal injuries from interactions with passenger air bags in low-severity frontal crashes. During that time, it is estimated that passenger air bags saved the lives of 88 passengers age 13 or older.

OLDER DRIVERS AND AIR BAGS

- The data lead to a preliminary conclusion that air bags are less effective for the driver age 70 or older than for the young or middle-aged driver.

AIR BAG EFFECTIVENESS FOR UNBELTED VS. BELTED CAR DRIVERS

- For drivers reported as **unbelted** in FARS, air bags reduced fatality risk by a statistically significant 34 percent in purely frontal impacts (confidence bounds: 25 to 42 percent).

- For drivers reported as **belted** in FARS, air bags reduced fatality risk by a statistically significant 21 percent in purely frontal impacts (confidence bounds: 9 to 33 percent). In other words, in a purely frontal impact, a belted driver has 21 percent lower fatality risk in a car equipped with an air bag than in a similar car without an air bag.

- In States with low belt use, the overall fatality reduction for driver air bags was statistically significant in purely frontal crashes. In States with high belt use, the reduction was also significant, but not quite as large as in the States with low belt use.

- Based on the preceding analyses, it is concluded that air bags save lives for unbelted drivers, and that they save lives for belted drivers.

- It is also concluded that air bags are probably somewhat more effective, in relative terms, for the unbelted driver than for the belted driver.

- The overall fatality reduction by air bags for unbelted drivers **in all crashes** (not just purely frontal impacts) is estimated to be 13 percent (confidence bounds: 6 to 19 percent).

- The supplemental fatality reduction by air bags for belted drivers **in all crashes** is estimated to be 9 percent (confidence bounds: 3 to 15 percent).

SMALL VS. LARGE CARS

- The observed overall fatality reduction by air bags is about the same in light-weight, medium-weight and heavy cars. It is concluded that air bags are effective in small cars, and quite possibly no less effective, in relative terms, than in large cars.

CHAPTER 1

OVERALL FATALITY REDUCTION FOR AIR BAGS

1.1 Overview of the automatic protection requirement

Federal Motor Vehicle Safety Standard 208 ("Occupant Crash Protection"), as amended on July 17, 1984, required that automatic occupant protection, such as air bags or automatic belts, be phased into passenger cars during 1987-90 [2], Part 571.208; [10]. When the National Highway Traffic Safety Administration (NHTSA) issued FMVSS 208, it also began a continuing, nationwide effort to increase belt use through encouragement of State buckle-up laws, enforcement and public education. Use of manual lap and shoulder belts reduces the risk of fatal injury to front-seat occupants by 45 percent, but in 1983, only 14 percent of the general driver population buckled up [13], pp. IV-11 - IV-16; [26]. Initially, automatic belts installed in response to FMVSS 208 helped increase belt use. In the long run, however, NHTSA believed that the best protection would come from air bags in combination with buckle-up laws in most of the States to ensure high rates of belt use.

The actual course of events after 1984 was even better than what the agency had hoped for. Public consciousness of health and safety issues generally, and road safety in particular, increased during the 1980's. The FMVSS 208 regulation broke the logjam on belt laws. Many States passed buckle-up laws, and belt use tripled between 1984 and 1987 [6], p. 12. By 1995, all of the States plus the District of Columbia and Puerto Rico had enacted them. The public expressed an almost immediate preference for air bags over automatic belts, and the manufacturers moved quickly to meet the demand for air bags. By the early 1990's it was clear that the United States was heading for an all-air bag fleet and nearly universal belt laws that have a high level of public support. Automatic belts have become essentially irrelevant, since belt laws have greatly increased use of manual belts. As of model year 1995, automatic belts have been largely phased out of cars and light trucks. Two past evaluations of fatality reduction consistently showed that most types of automatic belts have about the same net effect as manual belts; one type (motorized belts without disconnect) perhaps offers a slight additional benefit over manual belts, because the use rate of the shoulder belt is very high, although the use of the manual lap belt is low [6], [19]. Since the effectiveness estimates in those studies were based on large samples of accident data, no further evaluation of automatic belt effectiveness is performed in this report.

Air bags evolved first for drivers and only later for right-front passengers. To encourage the early installation of air bags, even if only for drivers, FMVSS 208 excluded the right-front passenger position from the automatic protection requirement in cars with driver air bags produced before September 1, 1993. Since model year 1994, automatic protection (but not necessarily air bags) has been required at both positions in all new cars. This feature of FMVSS 208 has resulted in a large fleet of cars with an air bag and manual belts for the driver, and manual belts only for the right-front passenger. This feature, and the strong consumer demand for air bags have also resulted in a wide variety of combinations of belts and bags in cars. Up to model year 1991, with few exceptions, only six types of automatic protection were installed in cars:

(1) Driver air bag plus manual 3-point belts for the driver and the right-front passenger
(2) Driver and right-front passenger air bags with manual 3-point belts
(3) Motorized 2-point belts without disconnect, plus manual lap belts
(4) Motorized 2 point belts with disconnect, plus manual lap belts
(5) Nonmotorized, door-mounted 3-point belts
(6) Nonmotorized, door-mounted 2 point belts, usually with manual lap belts

In 1992-93, however, combinations of an air bag(s) and automatic belts became fairly common as manufacturers endeavored to install air bags as soon as possible but left unchanged the automatic belt systems that were already installed in that make-model in a previous year. In 1994, when all cars had to have automatic protection at both positions, but not all cars were ready for dual air bags, about 30 percent of the fleet had an air bag for the driver and an automatic belt at the right-front seat only, or at both positions.

In 1991, NHTSA extended the automatic occupant protection requirements to light trucks - pickup trucks, vans and sport utility vehicles (SUV) - to be phased in during model years 1995-98 [2]. Manufacturers are almost always using air bags, not automatic belts, to meet the requirement. They also installed a large number of driver-only air bags, in advance of the FMVSS.

In accordance with the Intermodal Surface Transportation Efficiency Act of 1991, FMVSS 208 was again amended to require all passenger cars manufactured after September 1, 1997 and all light trucks manufactured after September 1, 1998 to have dual air bags, plus lap and shoulder belts [2]. Automatic belts, and the combinations of air bags with automatic belts, will be phased out. Already, in model year 1995, the overwhelming majority of new cars have dual air bags and manual belts.

1.2 Fatalities, as of early 1996, at seating positions equipped with air bags

NHTSA periodically evaluates the effectiveness of the occupant protection program in accordance with a plan published in 1990 [11] and in response to Executive Order 12866 [12] and the Intermodal Surface Transportation Efficiency Act of 1991. Agency staff have published two analyses of fatality reduction by air bags. The agency's June 1992 Interim Report on the *Evaluation of the Effectiveness of Occupant Protection* was based on Fatal Accident Reporting System (FARS) data through mid-1991 [6]. At that time there were records of 790 occupant fatalities in passenger cars at seating positions equipped with air bags: 777 drivers and 13 right-front passengers. There were enough data to show a statistically significant reduction of driver fatalities in frontal crashes, and to support a conclusion that driver air bags save lives in passenger cars. They were not enough data for analyses of subgroups of drivers, vehicles or crashes. *Fatality Reduction by Automatic Occupant Protection in the United States*, Kahane's 1994 paper at the conference on the Enhancement of Safety in Vehicles (ESV), was based on FARS data through mid-1993, including records of 2107 occupant fatalities in passenger cars at seating positions equipped with air bags (2069 drivers and 38 right-front passengers) [19]. That is almost three times as many fatal cases as in the Interim Report, enough to show statistically significant fatality reductions for driver air bags by several analysis methods, and to reveal that air bags were quite effective in straight-ahead (12:00) frontal impacts, but not in oblique frontal impacts.

The current analysis includes FARS data through early 1996. There are 9609 records of fatalities at seating positions equipped with air bags, more than four times the data in the ESV paper. They include 7933 car drivers, enough for fairly detailed analyses of fatality reduction by vehicle size, occupant age, etc. They also include 782 car passengers and 855 light-truck drivers: large enough numbers for initial analyses of overall fatality reduction with good prospects of obtaining statistically significant results (i.e., about the same number of cases as existed for car drivers in the 1992 Interim Report). Only the 39 light-truck passengers are too few for any analysis.

The current study, as well as the two earlier ones, are **statistical** analyses. They look at large numbers of crashes, in the aggregate, to compare the fatality rate in vehicles equipped with air bags to the rate in comparable vehicles without air bags. They do not inspect the crashes one-by-one to find out the mechanism of fatal injury, or how the air bag performed, or even if it deployed. We may presume that a large proportion of the 9609 "fatalities at seating positions equipped with air bags" involved injury mechanisms entirely unrelated to the air bag (the nonfrontal impacts, for example). Conversely, when a person survives a crash at a seating position equipped with an air bag, the FARS data do not tell us if the air bag was responsible for that individual's survival. All the data tell us is whether vehicles equipped with air bags have lower fatality rates than comparable vehicles without air bags and, all else being equal, the difference in the fatality rates can be attributed to the air bag.

The current population of vehicles equipped with driver air bags is not only much larger than it was a few years ago; it is also far more representative. In model years 1985-88, air bags were primarily installed in luxury cars such as Mercedes and BMW. By contrast, during 1989-90 manufacturers concentrated on introducing air bags into sporty cars with a high proportion of young drivers (where they were needed most), such as Dodge Daytona, Ford Mustang, Pontiac Firebird, Mazda Miata and Toyota Celica. The first large company to install driver air bags in all of their new cars was Chrysler, during 1988-90. Increasingly, they became standard on typical "family" cars such as Ford Taurus (1990), Chevrolet Corsica (1991), Honda Accord and Toyota Camry (1992). By the end of model year 1993, air bags were common in all market classes of cars. Over 80 percent of MY 94 cars and over 95 percent of MY 95 cars had driver air bags. In early 1996, the cumulative roll, by manufacturer, of occupant fatalities at seat positions equipped with air bags did not look too different from the overall distribution of cars on the road in the United States:

General Motors	2615	Ford	2164	Chrysler	1602
Honda/Acura	627	Toyota/Lexus	570	Nissan/Infiniti	256
Mercedes	218	Mazda	191	BMW	112
Mitsubishi	112	Volvo	51	Hyundai	48
Subaru	42	VW/Audi	36	Porsche	25
Saab	22	Isuzu	14	Jaguar	8
Suzuki	2				

Dual air bags were also initially installed in luxury cars, such as Porsche, Lincoln and Mercedes, during 1987-91. These early installations, however, were few in number, and they account for only about 20 percent of the passenger fatalities to date. Most of the data come from 1993-95 model cars. When the shift from single to dual air bags began in 1993, it was rapid, and it tended to involve all car lines at about the same time. That makes the dual air-bag cars with right-front passenger fatalities quite representative of the late-model (1993-95) passenger car fleet.

Chrysler Corporation minivans, such as Dodge Caravan and Plymouth Voyager, were the first light trucks equipped with driver air bags, on a partial basis in model year 1991 and as standard equipment in 1992. That was four years in advance of the phase-in required by FMVSS 208. People who buy minivans tend to be safety-conscious, since the vehicles are typically used for transporting families and children. Thus, probably in response to consumer demand, other minivans also offered driver air bags early: Ford Aerostar and Toyota Previa (1992), Mazda MPV (1993), GM Astro/Safari and Nissan Quest (1994). Air bags did not appear in pickup trucks until 1994, and they were not installed on the majority of pickup trucks and SUV until 1995. As a result, the 855 driver fatality cases are not representative of the light-truck fleet, but include an overrepresentation of minivans. In 1994, Chrysler Corporation minivans and Toyota Previa also became the first light trucks with standard dual air bags; Ford Windstar and Isuzu Trooper followed in 1995.

Appendices A and B list the types of occupant protection installed in each make-model of passenger cars and light trucks, by model year.

1.3 FARS data preparation

The Fatal Accident Reporting System (FARS) provides a census of fatalities in motor vehicle crashes in the United States since 1975, including drivers and right-front passengers of passenger cars and light trucks [9]. As of August 1996, the FARS file is essentially complete through 1995 and it includes a substantial number of cases from the first quarter of 1996. The study is based on FARS records of model year 1985-95 passenger cars involved in fatal crashes during calendar years 1986-96, and model year 1989-95 light trucks in fatal crashes during calendar years 1988-96.

The first 10 characters of the Vehicle Identification Number (VIN) are listed for most of the vehicle records on FARS. As in both previous evaluations of occupant protection, all information in this study about the make, model, model year and type of occupant protection in a particular vehicle was derived from analysis of the VIN, based on various sources in the literature [1], [3], [22], [23], [25]. A series of programs, written or updated by NHTSA staff for this evaluation, selects model year 1985-95 vehicles based on the 10th character of the VIN, identifies the manufacturer and make from the first 3 characters and the specific model from characters 4-8 (and excludes trucks over 10,000 pounds Gross Vehicle Weight, motorcycles and other vehicles that are not cars or light trucks), and classifies the type of occupant protection for the driver and the right-front passenger, based on specific VIN characters and/or manufacturer-supplied information on what is standard equipment in a given make-model-year (see Appendices A and B).

Vehicle records where the VIN was unreported were excluded from the study. VINs that could not be deciphered to indicate the make-model and the type of occupant protection, either because of an error in the reporting of the VIN or because the type of occupant protection is not decipherable from the VIN, were also excluded. As an additional precaution, records were excluded if the FARS-reported model year was inconsistent with the model year decoded from the 10th character of the VIN. As a result, approximately 5½ percent of FARS records are excluded from the analysis:

0.9% Model year not reported on FARS
2.5% VIN not reported on FARS
1.0% FARS and VIN model years inconsistent
0.9% Error in VIN: could not determine manufacturer/make/model
0.3% Unknown occupant protection: error in VIN (cars), or not known from VIN (light trucks)

Each vehicle included in the analysis is classified by two four-digit codes derived from NHTSA's VIN analysis: the fundamental car [or light truck] group (CG) and specific make-model (MM2). These codes replace any make-model information already on FARS. Each car or light truck group comprises one or more make-models sharing a body platform. For example, all GM N-body cars (Buick Skylark, Oldsmobile Calais and Achieva, Pontiac Grand Am) belong to the same car group. When a car or truck gets a major redesign, a new group is defined - e.g. Honda Accord in 1990, or GM C/K pickups in 1988. Vehicles with a "shared body platform" belong to the same functional class (car, pickup, SUV or van) and usually have the same wheelbase, track width and primary drive system (front-wheel or rear-wheel). Different make-models in the same car group are sometimes nearly identical "corporate cousins" (Ford Tempo and Mercury Topaz, Dodge Caravan and Plymouth Voyager), or they may be recognizably different vehicles on the same platform (1985 Cadillac Seville and Eldorado). It should be noted that the same make-model code may be used for two quite different vehicles in two separate car groups, even in the same year: e.g., 1988 Buick LeSabre H-body sedan or a B-body station wagon. (The specific make-model codes for passenger cars, but not trucks, as shown in Appendix A, are usually, but not always identical to the codes of the pre-1991 FARS variable MAK_MOD.)

The type of occupant protection is indicated by yet another 4-digit code. The first digit indicates if an air bag was installed for the driver, the third digit, for the right-front passenger:

0 No air bag at that seat position
1 Air-bag equipped at that position

The second digit indicates the type of belt system for the driver, the fourth for the right-front passenger:

0 Manual 3-point belt
3 Motorized 2-point belt without disconnect, plus manual lap belt
4 Motorized 2 point belt with disconnect, plus manual lap belt
5 Nonmotorized, door-mounted 3-point belt
6 Nonmotorized, door-mounted 2 point belt, plus manual lap belt
7 Nonmotorized, door-mounted 2 point belt, plus knee bolster (no lap belt)

Thus, for example, a code of 1004 indicates that a car is equipped with an air bag and manual 3-point belt for the driver; no air bag, a motorized 2 point belt with disconnect, and a manual lap belt for the right-front passenger. A code of "9" indicates unknown occupant protection system: those vehicles are not included in any of the analyses.

Other variables are taken directly from the FARS records, such as the first harmful event and the number of vehicles involved in the accident; the initial and principal damage location on the subject vehicle (IMPACT1 and IMPACT2), and its most harmful event; and the injury severity, age, sex and FARS-reported belt use of the driver and the right-front passenger. Even though the FARS variables IMPACT1 and IMPACT2 use an "o'clock" reporting scheme, they indicate damage location, not necessarily direction of force. Thus, IMPACT2 = 1 indicates primary damage on the right-front corner, but not necessarily with a 1:00 principal direction of force. Except for certain statistics in Chapter 3, none of the analyses of this report rely on the FARS-reported belt use variable.

1.4 Definitions of "fatality reduction"

There are two separate ways to measure fatality reduction by air bags. The measure used in this chapter and the next one is the net, overall **"as used"** fatality reduction. This is the average effect of air bags for the entire population of occupants, including those who use their belts and those who don't. For example, the fatality risk for all drivers of cars with driver air bags (some of whom currently use the belts provided in those cars, some of whom do not) is compared to the risk for all drivers of similar cars without air bags, but with the same belt systems at the same use rates. The fatality reduction, or effectiveness, is the relative difference of the two risks. The effectiveness estimate comprises all crashes: those where the bag deployed and those where it didn't.

NHTSA is also interested in obtaining two estimates of **"when used"** fatality reduction by air bags:

(1) Air bag effectiveness for **unrestrained** drivers: the relative difference between the fatality risk of the unrestrained drivers of cars equipped with air bags and the unrestrained drivers of similar cars without air bags.

(2) Air bag effectiveness for **belted** drivers: the relative difference between the fatality risk of the belted drivers of cars equipped with air bags and the belted drivers of similar cars without air bags - i.e., the relative incremental effect of belts plus bags over belts alone.

The "as used" fatality reduction is essentially a weighted average of these two "when used" estimates. The terms "as used" and "when used" pertain to the **belt** use of the occupants, not their "use" of the air bags: in all cases, nondeployment as well as deployment crashes are included in the estimates.

The principal advantage of "as used" fatality reduction is that it is much easier to estimate accurately from FARS data. All FARS cases are included in the analysis, regardless of whether the occupants were belted or unrestrained. If we knew which of these occupants were actually belted and which were unrestrained, we could split them into two groups according to their belt use, and compute the two "when used" estimates. However, the consensus is that FARS does not necessarily contain accurate information about the belt use of crash survivors, especially in recent years [24]. Chapter 3 describes several attempts to obtain approximate estimates of "when used" fatality reduction without relying on FARS belt-use reporting for crash survivors or, preferably, for any of the occupants.

The measure of fatality reduction in this report is, at first glance, quite different from NHTSA's two previous evaluations. Those studies estimated the effect of the total occupant protection program: lives saved by air bags **plus** lives saved by increases in belt use after 1983. The effectiveness estimates, superficially, looked much higher in the earlier reports because the benefits of increased belt use were added to the benefits of the air bags. On closer examination, however, the analytic techniques of this report are nearly the same as in the two previous ones. In all cases, the primary analysis estimated the **incremental** benefit of air bags plus belts, at current belt use rates, over belts alone, at current use rates (and this reduction was 14 percent in the 1992 evaluation and 10 percent in the 1994 paper). Subsequently, in the two earlier studies, an additional savings for the increase in belt use from 1983 to the time of the study was merely "tacked on" to the primary estimate to obtain the effect of the total occupant protection program since 1983 (which was a 23 percent reduction in both studies). This study focuses exclusively on the benefits of air bags, not belts.

1.5 Fatality reduction for driver air bags - passenger cars

To compute fatality reduction, it says in the preceding section, the fatality **risk** for all drivers of cars with driver air bags should be compared to the corresponding risk for all drivers of **similar** cars without air bags. The key words that need more explanation are "risk" and "similar." Fatality "risk" with air bags, throughout this report, is a **ratio of fatalities**: the number of deaths for a specific group of occupants or crashes that could be affected by air bags divided by the number of fatalities of some control group of occupants or crashes who will not likely be affected by the air bags. "Similar" cars are the same makes and models as the air bag cars, in adjacent model years, and excluding make-models that were substantially redesigned at the time they got air bags.

A principal task is to identify groups of crashes or occupants that will be helped by air bags as well as control groups that are unlikely to be helped by air bags. One factor in the phase-in process for FMVSS 208 aided the analysis. The regulation excluded the right-front passenger position from automatic protection until September 1, 1993 in cars with driver air bags. Through model year 1993, over 90 percent of the cars equipped with air bags had them only for the driver. In cars with driver-only air bags, the right-front passengers are a "control group": they are unlikely to be helped by the [driver] bags.

The ratio of driver to right-front passenger fatalities in cars with driver air bags **(in crash-involved cars where both seats were occupied)** is compared to the corresponding ratio in earlier cars of the same makes and models, equipped only with belts at both positions. Cars in which the passenger was less than 5 years old are not included in this analysis. The effectiveness of air bags is estimated by the relative difference in the ratios. This procedure is called "double pair comparison analysis" [7]. The only real disadvantage of this method is that the analysis has to be limited to cars where both seats are occupied (about 1/3 of the fatality data sample).

Table 1-1 lists make-models that had manual **or** automatic 3-point belts only, and then, at some point during 1986-95, added driver air bags while retaining the 3-point belts. Make-models that always had driver air bags are excluded from the analysis, since there are no corresponding cars without them. Cars with dual air bags are excluded since the right-front passengers are not "a control group unaffected by air bags." Cars with any kind of **2-point** automatic belts are also excluded. If these

TABLE 1-1 - CAR DRIVERS: MAKE-MODELS THAT HAD MANUAL OR AUTOMATIC 3-POINT BELTS AND ADDED DRIVER AIR BAGS WITHOUT CHANGING THE BELT SYSTEM

MODEL YEARS INCLUDED IN THE EFFECTIVENESS ANALYSES

Make-Model		Model Years with 3-Point Belts Only	Model Years with Driver Air Bags
Chrysler	LeBaron	1987-88	1988-90
	New Yorker C	1989	1990-92
Dodge	Daytona	1986-88	1988-90
	Diplomat	1988	1988-89
	Dynasty	1988-89	1990-91
	Omni	1989	1990
	Shadow	1987-89	1990-92
	Spirit	1989	1990
Plymouth	Acclaim	1989	1990
	Gran Fury	1988	1988-89
	Horizon	1989	1990
	Sundance	1987-89	1990-92
Ford	Crown Victoria	1987-89	1990-92**
	Mustang	1988-89	1990-92
	Taurus	1988-89	1990-92**
Lincoln	Continental	1988	1989-90**
	Mark 7	1989	1990-92
	Town Car*	1988-89	1990-91**
Mercury	Grand Marquis	1987-89	1990-92**
	Sable	1988-89	1990-92**
Buick	Century*	1991-93	1993-95
	Electra*	1988-90	1991-93
	full-size wagon*	1988-90	1991-92
	LeSabre*	1989-91	1992-93
	Reatta	1988-89	1990-91
	Regal*	1993	1994
	Riviera***	1987-89	1990-92
	Skylark	1992-93	1994-95
Cadillac	Allante	1988-89	1990-93
	DeVille*	1987-89	1989-92
	Eldorado***	1987-89	1990-92
	Seville***	1987-89	1990-91
Chevrolet	Beretta***	1989-90	1991-93
	Camaro	1988-89	1990-92
	Caprice*	1988-90	1991-93
	Corsica***	1989-90	1991-93
	Corvette	1987-89	1990-92
Geo	Spectrum, Storm	1987-89	1990-92
Oldsmobile	Achieva	1992-93	1994-95
	Custom Cruiser*	1989-90	1991-92
	Cutlass Ciera*	1991-93	1993-95
	Cutlass Supreme*	1992-93	1994
	Delta 88*	1990-91	1990-93
	98*	1989-90	1989-93
	Toronado***	1988-89	1990-92
Pontiac	Bonneville*	1990-91	1992-93**
	Firebird	1988-89	1990-92
	Grand Am	1992-93	1994-95

Make-Model		Model Years with 3-Point Belts Only	Model Years with Driver Air Bags
VW	Cabriolet	1989	1990-92
Audi	5000/100/200*	1988-89	1989-91
	80/90*	1988-89	1990-92
BMW	300	1988-89	1990-92
	500	1987-89	1989-91
	600	1987	1988-89
	700	1985-87	1987-88
Nissan	300ZX	1990-91	1991-93
	Pulsar/NX	1989	1990-92
	Sentra	1993-94	1993-94
Honda	Accord	1988-89	1991-93**
	Civic	1989-91	1992-93
	Prelude*	1989-91	1992-93**
Acura	Legend*	1986-88	1987-90
Jaguar	XJ-S*	1987-89	1990-92
Mazda	RX7	1989	1990-91
Mercedes	basic sedan*	1985	1986
	190	1985	1985-86
	S and SEL	1985	1985
	SL Roadster	1985	1986
Saab	900*	1988-89	1990-92
	9000	1987-89	1988-92
Toyota	Celica	1987-89	1990-92
	Supra	1989	1990-91
	MR-2	1987-89	1991-93
Volvo	240*	1988-89	1990-92
	740*	1987-89	1987-92
	760*	1985-87	1987-90

* Make-model(s) switched to ABS in the same year as air bags: **excluded from the analysis of frontal vs. nonfrontal fatalities**

** Some of the cars have dual air bags; these cars are **excluded from the analyses**

*** Make-model switched to ABS 1-2 years before or after air bags: **frontal-nonfrontal analysis limited to selected model years with the same ABS status**

cars switched from 2-point to 3-point belts when they got air bags, some of the change in the fatality risk could be due to the change in the belts, not the air bags. But even if they kept the 2-point belts while adding air bags (as was not unusual in 1993-94), this is a configuration that will soon be phased out and is not characteristic of the future vehicle fleet. Automatic **3-point** belts, on the other hand, were included in the analysis. Their use rates and other characteristics are close enough to manual 3-point belts that they may be considered essentially the same thing, at least for statistical analyses of overall air-bag effectiveness [6], [19].

Table 1-1 shows the ranges of model years used in the analysis. The maximum range permitted was 6 model years - the first 3 years with air bags, vs. the last 3 years without them - but in most cases a shorter range was selected. The purpose of limiting the model-year range is to prevent excess disparity in vehicle ages between the air-bag equipped and the belt-only cars. As cars get substantially older, their distribution of accident types changes, possibly biasing the analyses (but not so much in this case, since most vehicle-age biases would have about the same effect on the driver and the right-front passenger fatalities). If a make-model was introduced, discontinued, or substantially redesigned less than 3 years before or after the switch to driver air bags, the range has to be cut off at that point. A final criterion for selecting the range is to assure that each make-model has an accident sample of belt-only cars as close as possible to **double** its air-bag equipped sample. A uniform ratio of belt-only to air-bag cars, by make-model, assures that the belt-only and air-bag samples have a similar make-model mix (thereby avoiding, for example, a bias due to an overrepresentation of sporty cars in one group or the other). In this particular data set, a target ratio of **two** belt-only cars to one air-bag equipped car is, heuristically, the best: a smaller ratio would increase sampling error because it would reduce the sample of belt-only cars; a larger ratio cannot be achieved, in many make-models, without using more than 3 model years of belt-only cars, increasing the possibility of vehicle-age biases.

Table 1-2 computes the fatality reduction with driver air bags in passenger cars. There were 2516 driver fatalities and 2715 right-front passenger fatalities in the cars with 3-point belts only, a risk ratio of .927. In other words, without air bags, fatality risk for the driver is just slightly less than for the right-front passenger. But in the matching make-models equipped with driver air bags, there were only 1313 driver fatalities (with air bags) as opposed to 1567 right-front passenger fatalities (without air bags), a risk ratio of .838. That is a 10 percent reduction in the fatality risk ratio associated with driver air bags, and it is statistically significant at the .05 level: Chi-square (χ^2) for the 2 x 2 table is 4.69 (χ^2 has to be at least 3.84 for significance at the .05 level and 6.64 for significance at the .01 level. If air bags had no effect at all, we would hypothesize the same distribution of front-outboard fatalities, by seat position, in the belt-only and air bag-equipped cars; the χ^2 test for the 2 x 2 table of front-outboard fatalities by type of occupant protection and seat position tests the null hypothesis.)

Another distinctive characteristic of air bags, which leads to a second method for estimating effectiveness, is that they are primarily designed to deploy in impacts with a frontal or partially frontal direction of force. If an impact has no frontal force component, the air bag would not usually deploy and cannot be expected to have much effect on fatality risk. The fatalities in purely nonfrontal crashes act as a control group relative to the fatalities in frontal or partially frontal crashes. It is appropriate to use an inclusive definition of "frontal and partially frontal" crashes, encompassing even crashes with a modest frontal force component: crashes in which the initial **and/or** principal impact location is anywhere between 10:00 and 2:00 on FARS. (The inclusive definition of frontals was originally

TABLE 1-2 - CAR DRIVERS: EFFECTIVENESS OF DRIVER AIR BAGS
BASED ON REDUCTION OF DRIVER FATALITIES
RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

(both seats occupied; make-models that had manual or automatic
3-point belts and added driver air bags without changing the belt system)

	Driver Fatalities	**Right Front Fatalities**	**Risk Ratio**	**Percent Reduction**
Cars with belts only	2516	2715	.927	
Cars w. driver air bags	1313	1567	.838	10

(statistically significant difference: $\chi^2 = 4.69$)

TABLE 1-3 - CAR DRIVERS: EFFECTIVENESS OF DRIVER AIR BAGS
BASED ON REDUCTION OF FRONTAL FATALITIES
RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts
and added driver air bags without changing the belt system;
excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
Nonfrontal fatalities	1841	1121	
Frontal fatalities	3422	1691	19

(statistically significant difference: $\chi^2 = 18.33$)

Fatality reduction for driver air bags in all types of crashes: 12 percent

recommended by the Insurance Institute for Highway Safety in their October 1991 analysis of the fatality reduction for driver air bags in passenger cars [29].) "Nonfrontal" crashes include side and rear impacts (principal impact 3:00-9:00), rollovers and other noncollisions (as defined by their most harmful event) without a 10:00-2:00 initial or principal impact. (Collisions with unknown impact locations are excluded from the analysis.) The ratio of frontal to nonfrontal driver fatalities in cars with driver air bags ought to be lower than the corresponding ratio in earlier cars of the same makes and models, equipped only with 3-point belts. The effectiveness of air bags in **frontal** crashes is estimated by the relative difference in the ratios. This analysis has the disadvantage of relying on the assumption of zero effectiveness in nonfrontal crashes, but it allows a larger sample size than the preceding method (since it is not limited to cases where the right-front seat was occupied); however, with the narrow definition of "nonfrontal crashes" used here, we can be reasonably confident that these crashes are a true control group for air bags, except to the extent (if any) that impact locations might be grossly misreported in FARS.

Table 1-1 lists make-models that switched from 3-point belts only to driver air bags plus 3-point belts at some time during 1986-95. However, not all of these models are appropriate for the current analysis. Make-models that received Antilock Brake Systems (ABS) on all or most of the cars, simultaneous with or close to the switch to air bags must be excluded. Studies have shown that ABS is associated with a shift from frontal to nonfrontal fatal crashes [16], [20]. Drivers of cars with ABS are experiencing some reductions in frontal collisions with other vehicles and substantial increases in nonfrontal single-vehicle crashes such as rollovers and side impacts with fixed objects. If cars that got air bags and ABS at the same time were included in the analysis, the effect associated with current ABS systems (an increase in nonfrontal fatalities) would be mistakenly interpreted as a benefit for air bags (a reduced proportion of frontal relative to nonfrontal fatalities). The analysis has to be limited to make-models that never had ABS (e.g., Dodge Omni), or became equipped with ABS well before air bags (e.g, BMW 300) or well after (e.g., Chevrolet Camaro). Table 1-1 shows that some models are excluded entirely, because they got air bags and ABS at the same time. Others are included for just a limited range of model years, before and after the shift to air bags, during which their ABS status did not change. Quite a few models, especially General Motors and Volvo, are fully or partially excluded.

Table 1-3 presents the data needed to calculate the fatality reduction for driver air bags in frontal crashes, and overall. There were 3422 frontal driver fatalities and 1841 nonfrontal driver fatalities in the cars equipped only with 3-point belts. But in cars with air bags, there were only 1691 frontal driver fatalities as opposed to 1121 nonfrontal driver fatalities. This is evidently a substantial reduction in the ratio of frontal to nonfrontal fatalities. The relative reduction of frontal fatalities for driver air bags is

$$1 - [(1691/1121) / (3422/1841)] = \mathbf{19\ percent}$$

and it is statistically significant at the .01 level (χ^2 = 18.83; if air bags had no effect at all, we would hypothesize the same distribution of driver fatalities, by impact location, in the belt-only and air bag-equipped cars; the χ^2 test for the 2 x 2 table of driver fatalities by type of occupant protection and impact location tests the null hypothesis.). Given that air bags reduce fatalities by 19 percent in frontal crashes and have little effect in nonfrontal crashes, the overall fatality reduction for driver air bags is the weighted average of 19 and zero:

$$\{1 - [(1691/1121) / (3422/1841)]\} [3422 / (3422+1841)] = \mathbf{12\ percent}$$

In summary, two rather different methods for computing the fatality reduction for driver air bags in passenger cars yielded nearly identical results: 10 and 12 percent. In both analyses, the reduction was statistically significant. Given the consistency of the two results, their simple arithmetic average is probably the "best" estimate, at least in a heuristic sense: an 11 percent reduction of car driver fatalities by air bags.

An approximate sense of sampling errors and confidence bounds may be developed from the entries in Table 1-3, the table that includes the largest number of accident cases. The four numbers in the table, a_{11}, a_{12}, a_{21} and a_{22}, are counts of fatalities in different vehicle types and crash modes, and they can be considered independent Poisson variates. The effectiveness statistic in frontal crashes

$$E = 1 - R = 1 - [(a_{22}/a_{12}) / (a_{21}/a_{11})]$$

is based on a ratio of ratios, R, with approximate variance

$$V(R) \cong R^2 [1/a_{11} + 1/a_{12} + 1/a_{21} + 1/a_{22}]$$

In Table 1-3, where R = .81 and the table entries are 1841, 1121, 3422 and 1691, the standard deviation of effectiveness in frontal crashes is approximately

$$.81 [1/1841 + 1/1121 + 1/3422 + 1/1691]^{.5} = .0390$$

With the assumption that air bags have no effect in nonfrontal crashes, and with only trivial uncertainty about the proportion of fatalities in belt-only cars that is frontal, the standard deviation of effectiveness for all types of crashes is

$$.0390 [3422 / (1841 + 3422)] = .0254$$

Taking 1.645 standard deviations on either side of the "best" estimate of 11 percent yields approximate confidence bounds (two-sided $\alpha = .05$, i.e., 90 percent bounds):

$$.11 \pm 1.645 \times .0254 = 7 \text{ to } 15 \text{ percent fatality reduction}$$

The 11 percent fatality reduction for driver air bags in passenger cars is almost identical to what was found in the two previous NHTSA evaluations. In the 1992 Interim Report, the analysis of driver vs. right-front passenger fatalities found "an 11 percent fatality reduction for driver air bags relative to manual belts at *current* use rates" [6], p. 22. (The analysis of frontal vs. nonfrontal fatalities found an overall reduction of 13 percent for air bags relative to manual-belt cars at current use rates, but this finding is biased in favor of air bags, because cars that switched to ABS at the same time as air bags were not excluded from the analysis [6], p. 24.) In the 1994 ESV paper, the analysis of driver vs. right-front passenger fatalities found an 8 percent reduction for air bags relative to manual belts at current use rates, and the frontal vs. nonfrontal analysis indicated a 12 percent reduction: these two findings average out to a 10 percent reduction [19].

1.6 Fatality reduction for driver air bags - light trucks

The same analysis procedures - comparison of driver and right-front passenger fatalities, and comparison of frontal and nonfrontal fatalities - can be used to estimate fatality reduction for driver air bags in light trucks (vans, pickup trucks and SUV). Table 1-4 lists the models that switched from manual 3-point belts only to a driver air bag plus manual belts at some point during 1991-95. Table 1-4 also shows the ranges of model years used in the analysis. In general, the range is cut off when a make-model was substantially redesigned less than 3 years before or after the switch to driver air bags, but some exceptions were permitted to keep up the sample size: the Dodge D/W pickup was included even though it was significantly redesigned at the same time it got driver air bags, because

TABLE 1-4 - LIGHT TRUCK DRIVERS: MAKE-MODELS THAT HAD MANUAL 3-POINT BELTS AND ADDED DRIVER AIR BAGS WITHOUT CHANGING THE BELT SYSTEM

MODEL YEARS INCLUDED IN THE EFFECTIVENESS ANALYSES

Make-Model		Model Years with Manual Belts Only	Model Years with Driver Air Bags
Chrysler	Town & Country	1990	1992-93
Dodge	Caravan/Grand Caravan	1989-90	1992-93
	Dakota	1992-93	1994-95
	Ram pickup	1991-93	1994-95
	Ram van/wagon	1994	1995
Jeep	Cherokee	1994	1995
Plymouth	Voyager/Grand Voyager	1989-90	1992-93
Ford	Aerostar**	1989-91	1992-94
	Bronco*	1992-93	1994-95
	F pickup	1991-93	1994-95
	F supercab pickup	1994	1995
	Full-sized van/wagon	1992	1995
	Ranger	1994	1995
Chevy/GMC	Astro/Safari van	1992-93	1994-95
	10/20 cargo vans	1992-93	1994-95
	10 Sportvan/Rally	1992-93	1994-95
	C/K pickup*	1994	1995
	C/K 100 xtd cab*	1994	1995
	Lumina APV	1992-93	1994-95
	S/T Blazer/Jimmy	1994	1995
	S/T pickup	1993-94	1995
	Suburban	1994	1995
Oldsmobile	Silhouette	1992-93	1994-95
Pontiac	TransSport	1992-93	1994-95
Mazda	MPV	1991-92	1993-95
Toyota	Previa	1991	1992-93
	T-100 pickup	1993	1994-95
Mitsubishi	Montero*	1991-93	1994-95

* Make-model(s) switching from rear-wheel to four-wheel Antilock Brake Systems at about the same time as they were equipped with air bags: **excluded from the analysis of frontal vs. nonfrontal fatalities**

** Switched to rear-wheel ABS in 1990: **frontal-nonfrontal analysis limited to model years 1990-93**

it provides a substantial proportion of the pickup-truck data. The range of model years was also tailored to assure that each make-model has a belt-only accident sample as close as possible to **2.5 times** its air-bag equipped sample. That target ratio is, heuristically, the best: a smaller ratio would increase sampling error because it would reduce the sample of belt-only trucks; a larger ratio cannot be achieved, in many make-models, without using more than 3 model years of belt-only trucks. Table 1-4 notes that certain trucks changed their ABS status at some time during the applicable model-year range. Those models are excluded from the frontal-nonfrontal analysis, or included for a shorter range of model years (although there is little evidence, so far, that either two-wheel or four-wheel ABS has the same effect in trucks as in cars [15], or that inclusion of these models would have biased the analysis).

Table 1-5 analyzes the fatality reduction with driver air bags in light trucks, based on the comparison of driver and right-front passenger fatalities. In the selected make-models, there were 478 driver fatalities and 512 right-front passenger fatalities in the trucks equipped only with manual belts, a risk ratio of .934. In the trucks of the same make-models equipped with driver air bags, there were 215 driver fatalities (with air bags) as opposed to 241 right-front passenger fatalities (without air bags), a risk ratio of .892. That is a 4 percent reduction in the fatality risk ratio associated with air bags. The effect is not statistically significant (χ^2 = 0.16).

Table 1-6 calculates the fatality reduction for driver air bags in frontal relative to nonfrontal crashes, and overall. There were 1009 frontal and 410 nonfrontal driver fatalities in the trucks equipped only with manual belts. But in trucks with air bags, there were 394 frontal as opposed to 208 nonfrontal driver fatalities. The relative reduction of frontal fatalities for driver air bags is

$$1 - [(394/208) / (1009/410)] = \mathbf{23\ percent}$$

and it is statistically significant at the .05 level (χ^2 = 6.37). Given that air bags reduce fatalities by 23 percent in frontal crashes and have little effect in nonfrontal crashes, the overall fatality reduction for driver air bags is:

$$\{1 - [(394/208) / (1009/410)]\}\ [1009 / (1009 + 410)] = \mathbf{16\ percent}$$

The average of the results of the two analyses for light trucks, 10 percent, is similar to the effect found in passenger cars (11 percent).

1.7 Fatality reduction for passenger air bags - car passengers age 13 or older

Table 1-7 lists make-models that switched from a **driver** air bag plus manual or automatic 3-point belts to **dual** air bags plus 3-point belts at some point during 1989-95 and it shows the ranges of model years used in the analyses of the effectiveness of passenger bags. Models that had 2-point automatic belts before and/or after the switch to dual air bags, or that switched directly from no air bags to dual air bags are excluded. The criteria for accepting a make-model are a bit more lenient here than in the analyses of car driver air bags (Table 1-1), because the available number of accident cases is small and should not be further diminished if possible. For example, Ford Mustang, Honda Accord and Saab 900, among others, were included even though they were significantly redesigned at the time they got dual air bags; Dodge full-sized cars are treated as a single make-model even though the Dynasty (driver air bag) and Intrepid (dual air bag) are not identical cars. (In future studies, as the available pool of data grows, models like these will be dropped from the analysis.) The range of model years was also tailored to assure that each make-model has a driver-bag equipped

TABLE 1-5 - LIGHT TRUCK DRIVERS: EFFECTIVENESS OF DRIVER AIR BAGS
BASED ON REDUCTION OF DRIVER FATALITIES
RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

(both seats occupied; make-models that had manual 3-point belts
and added driver air bags without changing the belt system)

	Driver Fatalities	**Right Front Fatalities**	**Risk Ratio**	**Percent Reduction**
Trucks with belts only	478	512	.934	
Trucks w. driver air bags	215	241	.892	4

(not a statistically significant difference: $\chi^2 = 0.16$)

TABLE 1-6 - LIGHT TRUCK DRIVERS: EFFECTIVENESS OF DRIVER AIR BAGS
BASED ON REDUCTION OF FRONTAL FATALITIES
RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual 3-point belts and
added driver air bags without changing the belt system;
excludes make-models that changed ABS status at the time they got air bags)

	Trucks with Belts Only	**Trucks with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
Nonfrontal fatalities	410	208	
Frontal fatalities	1009	394	23

(statistically significant difference: $\chi^2 = 6.37$)

Fatality reduction for driver air bags in all types of crashes: 16 percent

TABLE 1-7 - CAR PASSENGERS: MAKE-MODELS THAT HAD DRIVER AIR BAGS WITH MANUAL/AUTOMATIC 3-POINT BELTS AND SWITCHED TO DUAL AIR BAGS WITHOUT CHANGING THE BELT SYSTEM

MODEL YEARS INCLUDED IN THE EFFECTIVENESS ANALYSES

Make-Model		Model Years with Driver Air Bags	Model Years with Dual Air Bags
Chrysler	5th Ave*/LH*	1990-93	1993-95
	LeBaron	1991-93	1994-95
Dodge	Dynasty/Intrepid*	1991-93	1993-95
	Stealth	1993	1994-95
Ford	Crown Victoria	1991-93	1992-95
	Mustang	1992-93	1994-95
	Probe	1993	1994-95
	Taurus	1990-93	1992-95
Lincoln	Mark7/8	1990-92	1993-95
	Town Car*	1990-91	1990-92
Mercury	Grand Marquis	1990-92	1992-95
	Sable	1990-92	1992-95
Buick	Electra	1992-93	1994-95
	LeSabre***	1992-93	1994-95
	Regal	1994	1995
	Riviera	1991-93	1995
	Roadmaster	1993	1994-95
Cadillac	DeVille	1992-93	1993-95
	Eldorado***	1990-92	1993-95
	Seville***	1990-92	1993-95
Chevrolet	Camaro*	1990-92	1993-95
	Caprice	1992-93	1994-95
	Corvette	1992-93	1994-95
Geo	Prizm	1993	1994
Oldsmobile	Cutlass Supreme	1994	1995
	Delta 88	1992-93	1994-95
	98	1992-93	1994-95
Pontiac	Bonneville***	1992-93	1992-95
	Firebird*	1990-92	1993-95

Make-Model		Model Years with Driver Air Bags	Model Years with Dual Air Bags
Audi	100/200	1991-92	1992-95
BMW	300	1991-93	1994-95
	500	1992-94	1994-95
	700	1990-92	1993-95
	850	1991-92	1993-95
Nissan	Sentra	1993-94	1995
	300ZX	1992-93	1994-95
Infiniti	M30/J30	1990-92	1993-95
	Q45	1991-93	1994-95
Honda	Accord	1991-93	1993-95
	Civic	1992-93	1994-95
	Del Sol	1993	1993-95
	Prelude	1992-93	1992-95
Acura	Legend	1988-92	1991-94
	NSX	1991-92	1993-95
	Vigor	1992-93	1993-94
Jaguar	XJ	1993-94	1994-95
	XJ-S	1990-93	1994-95
Mazda	Miata	1992-93	1994-95
	MX6/626	1993	1994-95
	RX7	1993	1994-95
Mercedes	basic sedan	1989-92	1989-93
	S and SEL	1987-91	1989-91
	SL Roadster	1987-90	1990-92
Saab	900	1992-94	1994-95
Subaru	Impreza	1993-94	1995
Toyota	Camry	1992-93	1994-95
	Celica*	1992-93	1994-95
	Corolla	1993	1994-95
	Supra	1990-93	1994-95
Lexus	ES300	1992-93	1994-95
	LS400	1992	1993-95
	SC300/400	1992	1993-95
Volvo	940	1991-93	1994-95
	960	1991-92	1993-95
Mitsubishi	3000GT	1991-93	1994-95
	Diamante*	1993	1994-95

* Make-model(s) switched to ABS in the same year as dual air bags: **excluded from the analysis of frontal vs. nonfrontal fatalities**

*** Make-model switched to ABS 1-2 years before or after dual air bags: **frontal-nonfrontal analysis limited to selected model years with the same ABS status**

accident sample as close as possible to **double** its dual-bag sample. That target ratio is, heuristically, the best: a smaller ratio would increase sampling error because it would reduce the sample of driver-bag cars; a larger ratio cannot be achieved, in many make-models, without using more than 3 model years of driver-bag cars. Table 1-7 shows that a few models are excluded entirely from the analysis of frontal vs. nonfrontal crashes, because they got dual air bags and ABS at the same time. Others are included for just a limited range of model years, before and after the shift to dual air bags, during which their ABS status did not change.

Unlike the driver population, right front passengers include infants and small children as well as teenagers and adults. There is extensive evidence from individual crash investigations, however, that child passengers, possibly up through age 12, are encountering unique hazards in their interactions with air bags that could cancel out their benefits or even result in higher fatality risk [14], [28]. There is reason to suspect the effect of passenger air bags could be quite different for children than for teenagers and adults. In this chapter, let us remove the relatively few records involving child passengers from the accident sample and concentrate on the passengers age 13 or older.

The comparison of driver and right-front passenger fatalities is carried out in reverse to estimate fatality reduction for passenger air bags. Now, the drivers (with driver air bags) are the "control group": they get no help from the passenger bags. The ratio of right-front passenger fatalities (age 13 or older) to driver fatalities in cars with dual air bags (**in crash-involved cars where both seats were occupied by people age 13 or older**) is compared to the corresponding ratio in earlier cars of the same makes and models, equipped only with driver air bags. The effectiveness of passenger air bags is estimated by the relative difference in the ratios. Table 1-8 analyzes the fatality reduction with passenger air bags, based on this method. In the selected make-models, there were 1043 right-front passenger fatalities and 823 driver fatalities in the cars equipped only with driver air bags and belts, a risk ratio of 1.267. In other words, the passenger, with no air bag, is at substantially higher risk than the driver, with an air bag. In the same make-models equipped with dual air bags, there were 501 right-front passenger fatalities and 475 driver fatalities, a risk ratio of 1.055 - i.e., a return to the slight disadvantage of the right-front seat relative to the driver seat, as was the case before either was equipped with air bags. That is a statistically significant 17 percent overall fatality reduction for passenger air bags when risk is measured relative to driver fatalities ($\chi^2 = 5.38$, $p < .05$).

The analysis of frontal vs. nonfrontal right-front passenger fatalities is the same as for drivers. Table 1-9 shows that there were 448 frontal and 332 nonfrontal right-front passenger fatalities in the cars equipped only with driver air bags. In cars with dual air bags, there were 182 frontal as opposed to 165 nonfrontal driver fatalities. The relative reduction of frontal fatalities for passenger air bags is

1 - [(182/165) / (448/332)] = **18 percent**

and it is not statistically significant ($\chi^2 = 2.42$). If passenger air bags reduce fatalities by 18 percent in frontal crashes and have little effect in nonfrontal crashes, the overall fatality reduction is:

{1 - [(182/165) / (448/332)]} [448 / (448+332)] = **10 percent**

The results of the two analyses average out to a fatality reduction of 13.5 percent for passengers age 13 or older, in all types of crashes, which is quite similar to the effect found for driver air bags in passenger cars (11 percent).

TABLE 1-8 - CAR PASSENGERS **AGE 13 OR OLDER**:
EFFECTIVENESS OF PASSENGER AIR BAGS, BASED ON REDUCTION OF RIGHT FRONT PASSENGER FATALITIES RELATIVE TO DRIVER FATALITIES

(both seats occupied; make-models that had driver air bags with manual/automatic 3-point belts and switched to dual air bags without changing the belt system)

	Right Front Fatalities	**Driver Fatalities**	**Risk Ratio**	**Percent Reduction**
Cars w. driver air bags	1043	823	1.267	
Cars w. dual air bags	501	475	1.055	17

(statistically significant difference: $\chi^2 = 5.38$)

TABLE 1-9 - CAR PASSENGERS **AGE 13 OR OLDER**:
EFFECTIVENESS OF PASSENGER AIR BAGS BASED ON REDUCTION OF FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had driver air bags with manual/automatic 3-point belts and switched to dual air bags without changing the belt system; excluding make-models that got ABS at the same time as dual air bags)

	Cars with Driver Air Bags	**Cars with Dual Air Bags**	**Frontal Fat. Red. for Passenger Bag (%)**
Nonfrontal fatalities	332	165	
Frontal fatalities	448	182	18

(not a statistically significant difference: $\chi^2 = 2.42$)

Fatality reduction for passenger air bags in all types of crashes: 10 percent

1.8 Estimated increase of fatalities, through 1995, if there had been no air bags

Given that driver air bags in passenger cars reduce fatalities by 11 percent (and assuming a similar effectiveness for car passengers and in light trucks), it is possible to infer, from the number of fatalities that have actually occurred at seating positions equipped with air bags, how many **additional** fatalities would have occurred if those vehicles had **not** been equipped with air bags. Table 1-10 presents the estimates. The left column of the table shows the cumulative total of fatalities at seat positions equipped with air bags, including drivers and right-front passengers in cars and light trucks, that were identified in FARS. The cumulative total of fatalities has grown from 109 as of 12/31/89 to 8688 through 12/31/95.

But the number of **identified** fatalities on FARS understates the **actual** fatality total. As explained in Section 1.3, approximately 5.5 percent of vehicle records on FARS were excluded from the analysis because the VIN was unreported or incorrectly reported, the model year was unknown, etc. Assuming that these excluded vehicles have the same proportion of air bags as the included ones, the actual fatalities can be estimated by dividing the identified total by (1 - .055), as shown in the second column of Table 1-10. Thus, by the end of 1995, the 8688 fatalities identified on FARS can be assumed to correspond to 9194 actual fatalities.

If the fatality reduction for air bags is 11 percent, these numbers of actual fatalities would have been higher if cars and light trucks had not been equipped with air bags. The 9194 fatalities at the end of 1995 would have increased to 9194 / (1 - .11) = 10,330. Thus, an additional 10,330 - 9194 = 1136 fatalities would have occurred, cumulative through 1995, if cars and light trucks had never been equipped with air bags. Given that the confidence bounds for fatality reduction are 7 to 15 percent (see Section 1.5), the confidence bounds for the increase in fatalities, if cars and light trucks had not been equipped with air bags, range from 692 to 1622 lives.

The 8688 fatalities identified on FARS include 675 right-front passengers age 13 or older in cars or light trucks equipped with dual air bags. Dividing by (1 - .055), as a correction for missing data, suggests that the 675 passenger fatalities identified on FARS correspond to 714 actual fatalities. If the fatality reduction by air bags is about the same for passengers age 13 or older as it is for drivers, 11 percent, these 714 actual fatalities would have increased to 714 / (1 - .11) = 802. Thus, an estimated 802 - 714 = 88 additional fatalities would have occurred among right-front passengers age 13 or older, cumulative through 1995, if no cars or light trucks had been equipped with dual air bags.

1.9 Summary of fatality reduction estimates

Table 1-11 summarizes the estimates of overall fatality reduction for driver and passenger air bags. The effectiveness of driver air bags in passenger cars was estimated by two analysis methods. Each yielded a statistically significant fatality reduction: the first method 10 percent, the second, 12 percent. We can be reasonably confident that the actual fatality reduction for car driver air bags is close to 11 percent, the average of the results by the two methods (confidence bounds for this reduction were estimated to be 7 to 15 percent, in Section 1.5).

The two analyses for driver air bags in light trucks, working with a much smaller data sample, gave

TABLE 1-10

ESTIMATE OF CUMULATIVE INCREASE IN FATALITIES IF THERE HAD BEEN NO DRIVER OR PASSENGER AIR BAGS IN CARS OR LIGHT TRUCKS

	Cumulative Fatalities at Seat Positions Equipped with Air Bags		**Cumulative Additional Fatalities If There Had Been No Air Bags§**
	Identified on FARS	**Actual (Estimated*)**	
12/31/89	109	115	14
12/31/90	390	413	51
12/31/91	924	978	121
12/31/92	1709	1808	223
12/31/93	3037	3214	397
12/31/94	5153	5453	674
12/31/95	8688	9194	1136

*Assuming 5.5% of fatal cases cannot be identified on FARS due to missing VINs, etc.

§ Assuming 11% fatality reduction for all types of air bags

TABLE 1-11

ESTIMATES OF OVERALL FATALITY REDUCTION FOR AIR BAGS

	Percent Fatality Reduction		
	Analysis Method		
	Compare Driver to Right Front*	Compare Frontal to Nonfrontal*	Average
Driver air bags for cars	***10***	***12***	11
Driver air bags for light trucks	4	***16***	10
Passenger air bags for cars (passengers age 13 or older)	***17***	10	13.5

******Statistically significant results are shown in bold italics.***

estimates of 4 percent and 16 percent. The second reduction is statistically significant. The results average to 10 percent, nearly identical with the fatality reduction for driver air bags in passenger cars.

The analyses for passenger air bags in cars, limited to passengers age 13 or older, produced overall fatality reductions of 17 percent and 10 percent, respectively. The first of these is statistically significant. The average of the two results, 13.5 percent, is nearly identical to the reduction for driver air bags in cars.

CHAPTER 2

FATALITY REDUCTION BY TYPE OF CRASH, VEHICLE OR OCCUPANT

2.1 By impact location

One of the principal findings of the 1994 NHTSA staff analysis of occupant protection [19] was that driver air bags reduced fatalities in passenger cars by approximately 30 percent in impacts with purely frontal damage (12:00 principal impact on the Fatal Accident Reporting System) but had little effect, if any, in impacts with front-corner or front-side damage (10, 11, 1 or 2 o'clock principal impact on FARS). The much larger accident data set now available enables us to update that analysis and to take a first look at these effects for driver air bags in light trucks and passenger air bags in cars.

Table 2-1 examines the fatality reduction for driver air bags in cars, based on a comparison of driver and right-front passenger fatalities in the cars. That analysis method, and the list of make-models included in the analysis, are defined in Section 1.5. The top section of Table 2-1 addresses "purely frontal" crashes in FARS: crashes with a 12:00 principal impact location, and in which the most harmful event is not a rollover. Note that a 12:00 principal impact location does not necessarily mean a 12:00 Principal Direction of Force (a variable not reported on FARS). The **damage** has to be in the front of the car, even though the force could come from a partly oblique direction (conversely, impacts with a 12:00 PDOF that result in front-corner or sideswipe damage are excluded).

Driver air bags are quite effective in purely frontal impacts. There were 825 driver fatalities and 867 right-front passenger fatalities in the cars with 3-point belts only, a risk ratio of .952. In other words, without air bags, fatality risk for the driver is just slightly less than for the right-front passenger in a pure frontal. But in the matching make-models equipped with driver air bags, there were only 313 driver fatalities (with air bags) as opposed to 498 right-front passenger fatalities (without air bags), a risk ratio of .629. That is a 34 percent reduction in the fatality risk ratio associated with driver air bags, and it is statistically significant at the .01 level ($\chi^2 = 23.55$).

The second section of Table 2-1 analyzes "partially frontal" crashes: all impacts, except the purely frontal ones, in which the initial **or** principal damage (or both) was between 10:00 and 2:00. This category includes some impacts that are primarily frontal in nature, such as principal impacts to the front corners (11:00 and 1:00). Also included are crashes where the frontal component is of secondary importance, such as side impacts toward the front of the car (10:00 and 2:00), frontal impacts followed by a most-harmful-event rollover, and multiple impacts in which the initial damage is frontal but the principal damage is not. The fatality risk ratio is essentially the same without air bags (.941) and with a driver air bag (.956). The observed effect for driver air bags is a 2 percent increase in fatality risk, and it is not statistically significant ($\chi^2 = 0.26$).

When the data for "purely frontal" and "partially frontal" crashes are combined, as shown in the third section of Table 2-1, the net effect for driver air bags is in between the two preceding results: an 18 percent fatality reduction in all frontal crashes, statistically significant at the .01 level ($\chi^2 = 10.40$).

TABLE 2-1 - CAR DRIVERS, **BY IMPACT LOCATION**:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

(both seats occupied; make-models that had manual or automatic
3-point belts and added driver air bags without changing the belt system)

	Driver Fatalities	**Right Front Fatalities**	**Risk Ratio**	**Percent Reduction**
IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Cars with belts only	825	867	.952	
Cars w. driver air bags	313	498	.629	34
(statistically significant difference: $\chi^2 = 23.85$)				
IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Cars with belts only	698	742	.941	
Cars w. driver air bags	390	408	.956	- 2
(not a statistically significant difference: $\chi^2 = 0.26$)				
IN ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)				
Cars with belts only	1523	1609	.947	
Cars w. driver air bags	703	906	.776	18
(statistically significant difference: $\chi^2 = 10.40$)				
IN NONFRONTAL CRASHES				
Cars with belts only	960	1079	.890	
Cars w. driver air bags	595	644	.924	- 4
(not a statistically significant difference: $\chi^2 = 0.27$)				

The last section of Table 2-1 is limited to nonfrontal crashes, in which the initial and principal impacts are both in the 3:00 - 9:00 range, or in which there was no collision at all (e.g., rollovers, immersions and fires without impact). Ideally, the data ought to indicate a zero effect for air bags here, since these crashes would generally not result in an air bag deployment; actually the data show a 4 percent increase with driver air bags that is not significantly different from zero ($\chi^2 = 0.27$) and is very much within the "noise" range, given the number of cases available for the statistical analysis.

Table 2-2 computes the fatality reduction in various subsets of frontal crashes by comparing them to a control group of nonfrontal crashes. That analysis method is documented in Section 1.5 and Table 1-3; the control group is the same in each case. The top section of Table 2-2 shows that there were 1905 purely frontal driver fatalities and 1841 nonfrontal driver fatalities in the cars equipped with just 3-point belts. But in cars with air bags, there were only 847 purely frontal driver fatalities as opposed to 1121 nonfrontals. In other words, there used to be slightly more pure-frontal than nonfrontal fatalities, but with air bags, there are now substantially fewer. The relative reduction of purely frontal fatalities for driver air bags,

1 - [(847/1121) / (1905/1841)] = **27 percent**

is statistically significant at the .01 level ($\chi^2 = 31.57$). (Even though the observed effect is slightly lower than the 34 percent in Table 2-1, the χ^2 statistic is higher because the analysis is based on a larger number of accident cases.)

The middle section of Table 2-2 indicates a 9 percent fatality reduction for air bags in partially frontal crashes. While that is better than the -2 percent effect in Table 2-1, it still appears negligible in comparison to the effect in pure-frontal crashes, and it is not statistically significant ($\chi^2 = 2.48$). The net effect of air bags in all frontal and partially frontal crashes is an 19 percent reduction, and it is statistically significant at the .01 level ($\chi^2 = 18.83$). Unlike Table 2-1, this method will not compute the fatality "reduction" for air bags in nonfrontal crashes; those crashes are a control group here, and the fatality reduction is assumed to be zero.

While Tables 2-1 and 2-2 obviously suggest that driver air bags are more effective in purely frontal than in partially frontal crashes, it would be desirable to confirm that conclusion by a statistical test., specifically, a χ^2 test on the 2 x 2 table of purely vs. partially frontal impact fatalities, gleaned from Table 2-2:

	No Air Bags	Air Bags
Purely frontal	1905	847
Partially frontal	1517	844

Since $\chi^2 = 14.18$ exceeds the quantity required for statistical significance at the .01 level, it may be inferred that air bags are more effective in purely frontal than partially frontal crashes.

The data set for driver air bags in **light trucks** is less than a fourth the size of the set for passenger cars. That increases sampling error in all the analyses, but especially in those based on driver vs. right-front passenger fatalities, that have to be limited to vehicles in which both seats were occupied.

TABLE 2-2 - CAR DRIVERS, **BY IMPACT LOCATION**:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts and added driver air bags without changing the belt system; excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	1841	1121	
Purely frontal fatalities	1905	847	27
(statistically significant difference: $\chi^2 = 31.57$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	1841	1121	
Partially frontal fatalities	1517	844	9
(not a statistically significant difference: $\chi^2 = 2.48$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	1841	1121	
Frontal fatalities	3422	1691	19
(statistically significant difference: $\chi^2 = 18.83$)			

Table 2-3 shows a 19 percent fatality reduction in purely frontal crashes, but with cell counts of 52 driver and 72 right-front fatalities in the trucks equipped with air bags, this effect is not statistically significant (χ^2 = 1.04). The other results in Table 2-3 - a 7 percent reduction in partially frontal crashes, a 11 percent reduction in all frontal crashes, and a 11 percent increase in nonfrontal crashes - likewise fall far short of statistical significance.

Table 2-4 compares frontal to nonfrontal driver fatalities in light trucks. Since these analyses can include trucks in which the right-front seat was unoccupied, the cell counts are substantially larger. The fatality reduction for driver air bags in purely frontal crashes is 35 percent, and it achieves statistical significance at the .01 level (χ^2 = 13.46). The reduction in partially frontal crashes is 7 percent, and it is not statistically significant (χ^2 = 0.33). The combined effect in all frontal crashes is a 23 percent fatality reduction, statistically significant at the .05 level (χ^2 = 6.37).

Tables 2-5 and 2-6 analyze the effectiveness of **passenger air bags** for car passengers age 13 or older. As was noted in Section 1.7 and will be further discussed in Section 2.6, there is extensive evidence from individual crash investigations that child passengers under age 13 can encounter unique hazards in their interactions with air bags that make their experience quite different from the teen-age and adult passenger population [14], [28]. Table 2-5 compares the fatality risk of right-front passengers age 13 or older to drivers, in cars with dual and driver-only air bags. It is based on substantially fewer data than the corresponding analyses for car drivers (Table 2-1), but more than those for light truck drivers (Table 2-3). In purely frontal crashes, the observed fatality reduction for passenger air bags, 24 percent, falls short of statistical significance (χ^2 = 2.67). Also positive, but nonsignificant, are the observed effects in partially frontal crashes (11 percent reduction), in all frontal crashes (18 percent) and in nonfrontal crashes (15 percent).

Table 2-6, based on a comparison of frontal to nonfrontal fatalities, yields results that are most consistent with the pattern seen for car and light-truck drivers. In purely frontal crashes, passenger air bags reduced the fatality risk of passengers age 13 or older by a statistically significant 30 percent (χ^2 = 5.05, $p < .05$). In partially frontal crashes, the effect is a nonsignificant 5 percent. The weighted average for all frontal crashes is an 18 percent reduction, falling short of statistical significance (χ^2 = 2.42).

Table 2-7 summarizes all the fatality reduction estimates, and averages the estimates by the two methods. The results, as presented in this table, show remarkable similarity in the effect of air bags for car drivers, light truck drivers, and car passengers age 13 or older. For car driver air bags, the fatality reduction in purely frontal impacts is statistically significant and close to 30 percent by each method: the average is 30.5 percent. The effect in partially frontal impacts is nonsignificant by both methods, and it averages out to a negligible 3.5 percent. The net effect in frontals averages to 18.5 percent, and the reduction is statistically significant by both methods.

The effects for driver air bags in light trucks, although based on far fewer data, average out to essentially the same results as for car drivers: the fatality reduction averages 27 percent in pure frontals, 7 percent in partial frontals, and 17 percent in all frontals. In the frontal vs. nonfrontal analysis, the observed reductions in purely frontal and all frontal crashes are both statistically significant.

TABLE 2-3 - LIGHT TRUCK DRIVERS, **BY IMPACT LOCATION**:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

(both seats occupied; make-models that had manual 3-point belts
and added driver air bags without changing the belt system)

	Driver Fatalities	**Right Front Fatalities**	**Risk Ratio**	**Percent Reduction**
	IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Trucks with belts only	164	183	.896	
Trucks w. driver air bags	52	72	.722	19
	(not a statistically significant difference: $\chi^2 = 1.04$)			
	IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Trucks with belts only	153	140	1.093	
Trucks w. driver air bags	76	75	1.013	7
	(not a statistically significant difference: $\chi^2 = 0.14$)			
	IN ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Trucks with belts only	317	323	.981	
Trucks w. driver air bags	128	147	.871	11
	(not a statistically significant difference: $\chi^2 = 0.69$)			
	IN NONFRONTAL CRASHES			
Trucks with belts only	156	184	.848	
Trucks w. driver air bags	86	91	.945	- 11
	(not a statistically significant difference: $\chi^2 = 0.34$)			

TABLE 2-4 - LIGHT TRUCK DRIVERS, **BY IMPACT LOCATION**:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual 3-point belts and added driver air bags without changing the belt system; excludes make-models that changed ABS status at the time they got air bags)

	Trucks with Belts Only	**Trucks with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
	PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)		
Nonfrontal fatalities	410	208	
Purely frontal fatalities	574	188	35
	(statistically significant difference: $\chi^2 = 13.46$)		
	PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)		
Nonfrontal fatalities	410	208	
Partially frontal fatalities	435	206	7
	(not a statistically significant difference: $\chi^2 = 0.33$)		
	ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)		
Nonfrontal fatalities	410	208	
Frontal fatalities	1009	394	23
	(statistically significant difference: $\chi^2 = 6.37$)		

TABLE 2-5 - CAR PASSENGERS **AGE 13 OR OLDER, BY IMPACT LOCATION**:
EFFECTIVENESS OF PASSENGER AIR BAGS BASED ON REDUCTION OF
RIGHT FRONT PASSENGER FATALITIES RELATIVE TO DRIVER FATALITIES

(both seats occupied; make-models that had driver air bags with manual/automatic 3-point belts and switched to dual air bags without changing the belt system)

	Right Front Fatalities	Driver Fatalities	Risk Ratio	Percent Reduction
IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Cars w. driver air bags	315	214	1.472	
Cars w. dual air bags	109	97	1.124	24
(not a statistically significant difference: $\chi^2 = 2.67$)				
IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Cars w. driver air bags	281	248	1.133	
Cars w. dual air bags	146	144	1.014	11
(not a statistically significant difference: $\chi^2 = 0.58$)				
IN ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)				
Cars w. driver air bags	596	462	1.290	
Cars w. dual air bags	255	241	1.058	18
(not a statistically significant difference: $\chi^2 = 3.30$)				
IN NONFRONTAL CRASHES				
Cars w. driver air bags	440	353	1.246	
Cars w. dual air bags	237	225	1.053	15
(not a statistically significant difference: $\chi^2 = 2.06$)				

TABLE 2-6- CAR PASSENGERS **AGE 13 OR OLDER, BY IMPACT LOCATION**:
EFFECTIVENESS OF PASSENGER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had driver air bags with manual/automatic 3-point belts
and switched to dual air bags without changing the belt system;
excluding make-models that got ABS at the same time as dual air bags)

	Cars with Driver Air Bags	**Cars with Dual Air Bags**	**Frontal Fat. Red. for Passenger Bag (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	332	165	
Purely frontal fatalities	236	82	30
(statistically significant difference: $\chi^2 = 5.05$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	332	165	
Partially frontal fatalities	212	100	5
(not a statistically significant difference: $\chi^2 = 0.11$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	332	165	
Frontal fatalities	448	182	18
(not a statistically significant difference: $\chi^2 = 2.42$)			

TABLE 2-7: SUMMARY
FATALITY REDUCTION FOR AIR BAGS **BY IMPACT LOCATION**

	Percent Fatality Reduction		
	Analysis Method		
	Compare Driver to Right Front*	Compare Frontal to Nonfrontal*	Average
Driver air bags for cars			
Purely frontal impacts	***34***	***27***	30.5
Partially frontal impacts	- 2	9	3.5
All frontal impacts	***18***	***19***	18.5
Nonfrontals	- 4		
Driver air bags for light trucks			
Purely frontal impacts	19	***35***	27
Partially frontal impacts	7	7	7
All frontal impacts	11	***23***	17
Nonfrontals	- 11		
Passenger air bags for cars: passengers age 13 or older			
Purely frontal impacts	24	***30***	27
Partially frontal impacts	11	5	8
All frontal impacts	18	18	18
Nonfrontals	15		

****Statistically significant results are shown in bold italics.***

Similarly, for car passengers age 13 or older, the fatality reduction for passenger air bags averages to 27 percent in purely frontal crashes, 8 percent in partial frontals, and 18 percent in all frontals. In short, air bags save lives for drivers and passengers age 13 or older, and most of their life-saving benefit is in the purely frontal crashes, with a limited effect, at best, in the partially frontal crashes.

Approximate 90 percent confidence bounds (i.e., two-sided $\alpha = .05$) for the fatality reductions in purely frontal crashes may be developed from the entries in the top sections of Tables 2-2, 2-4 and 2-6, using the same method as in Section 1.5. The four numbers in the table, a_{11}, a_{12}, a_{21} and a_{22}, are counts of fatalities in different vehicle types and crash modes, and they can be considered independent Poisson variates. The effectiveness statistic in frontal crashes

$$E = 1 - R = 1 - [(a_{22}/a_{12}) / (a_{21}/a_{11})]$$

is based on a ratio of ratios, R, with approximate variance

$$V(R) \cong R^2 [1/a_{11} + 1/a_{12} + 1/a_{21} + 1/a_{22}]$$

In Table 2-2 (car drivers), where R = .73 and the table entries are 1841, 1121, 1905 and 847, the standard deviation of effectiveness in frontal crashes is approximately

$$.73 [1/1841 + 1/1121 + 1/1905 + 1/847]^{.5} = .0409$$

Taking 1.645 standard deviations on either side of the "best" estimate of 30.5 percent yields approximate confidence bounds:

$$.305 \pm 1.645 \times .0409 = 24 \text{ to } 37 \text{ percent fatality reduction}$$

for car drivers in purely frontal crashes. Similarly, the confidence bounds of fatality reduction by air bags for light truck drivers in purely frontal crashes are 14 to 40 percent. The confidence bounds of fatality reduction by passenger air bags for car passengers age 13 or older in purely frontal crashes are 9 to 45 percent.

2.2 By car weight

The remaining analyses of this chapter, except for the discussion of child passengers in Section 2.6, are all limited to **driver air bags for cars**, since there are not enough data to perform corresponding analyses for car passengers or drivers of light trucks. One major question is whether the fatality reduction for air bags varies with the size of the car. Specifically, the 1991 study by the Insurance Institute for Highway Safety estimated a 36 percent overall fatality reduction for driver air bags in large cars, but only 13 percent in mid-sized cars and 9 percent in small cars [29], pp. 8-9. Even though the report did not assert that effectiveness was **significantly** higher in the large cars (which it probably wasn't, given the limited data available at that time), it touched on an issue that was already troubling researchers. Air bags might have a lower overall effect in small cars, they thought, for several reasons: (1) There is less room and time to deploy the bags in a small car [13], p. III-7; (2) A higher proportion of fatalities in small cars involve rollover or other circumstances where air bags are less likely to be effective [5]. In particular, since many of the early air bag installations were in large cars such as Mercedes, the early estimates of fatality reduction might be unrepresentative of the "average" car on the road, and the estimates might decline over time as more and more small cars became equipped with air bags.

Table 2-8 summarizes the fatality reductions for small, medium and large cars. The results in that table are derived from more detailed analyses shown in Tables C-1 - C-6 of Appendix C. "Small" cars are defined here as those with curb weight of 2778 pounds or less, accounting for one-third of

TABLE 2-8

FATALITY REDUCTION FOR CAR DRIVER AIR BAGS
BY CAR SIZE AND IMPACT LOCATION

	Percent Fatality Reduction		
	Analysis Method		
	Compare Driver to Right Front*	Compare Frontal to Nonfrontal*	Average
Cars up to 2778 pounds			
Purely frontal impacts	***28***	***31***	29.5
Partially frontal impacts	- 7	12	2.5
All crashes	7	***15***	11
Cars 2779-3119 pounds			
Purely frontal impacts	***31***	16	23.5
Partially frontal impacts	4	6	5
All crashes	9	8	8.5
Cars over 3119 pounds			
Purely frontal impacts	***43***	***34***	38.5
Partially frontal impacts	- 1	3	1
All crashes	13	***13***	13

****Statistically significant results are shown in bold italics.***

the cars in the accident data. Curb weights are derived from R. L. Polk's *National Vehicle Population Profile* [21], and they are averaged at the make-model level. Table 2-8 shows that the fatality reduction for driver air bags in purely frontal crashes is close to 30 percent, by both analysis methods, in small cars. Both reductions are statistically significant. The effect of air bags in partially frontal crashes averages out to barely above zero, and it is not statistically significant. The fatality reduction in all crashes averages to 11 percent, statistically significant in the frontal vs. nonfrontal analysis method.

The fatality reductions for cars in the middle third of the weight distribution, 2779-3119 pounds, are actually slightly lower, averaging 23.5 percent in purely frontal crashes, 5 percent in partially frontal crashes, and 8.5 percent overall. The observed fatality reduction in purely frontal crashes averages 38.5 percent in the large cars (weighing over 3119 pounds), slightly higher than for small and medium-sized cars. The average overall fatality reduction, 13 percent, is also slightly larger than in small or mid-size cars.

These results suggest that air bags are about as effective in small cars as in larger cars. The pattern and magnitudes of the fatality reductions are essentially the same in the three size groups. Although the observed results for large cars are slightly better than for small and mid-sized cars, there is no trend of increasing effectiveness as car size grows: the lowest observed reductions are generally in the mid-sized cars.

The absence of a significant trend is confirmed by a CATMOD analysis of the 3 x 2 x 2 table generated from the top sections of Tables C-4, C-5 and C-6 in Appendix C [27] - i.e., a tabulation of purely frontal vs. nonfrontal driver fatalities, by car weight group and type of occupant protection (driver air bag, no air bag); the car weight group is treated as a linear variable (2550, 3000 and 3450 pounds are the average weights in each group). Whereas the simple independent variable, "air bag" has a strong association with the dependent variable (proportion of fatalities that are pure frontals), as evidenced by $\chi^2 = 26.52$, $p < .01$, the interaction term air bag x weight group does not have significant association with the dependent variable ($\chi^2 = 0.08$).

A possible caveat on the findings on car weight is that the analyses are perhaps biased in favor of small cars, since they have, on the average, fewer old drivers. As will be shown in Section 2.5, air bags are not as effective for old drivers as for young or middle-aged drivers. However, even when these analyses are performed separately for drivers aged 14-55 and drivers over 55 years old, the overall fatality reduction in both age groups is about the same in small cars as in large cars.

2.3 By vehicle manufacturer

Air bags may vary in design features, such as the type of sensors, deployment rate, deployment threshold, etc. Conceivably, certain types of driver air bags might be substantially more effective than others. The issue can be partially addressed by calculating the fatality reduction separately for four groups of cars, each containing about a quarter of the accident cases: Chrysler Corp., Ford Motors, General Motors, and imports (including transplants). Based on the method of comparing driver fatalities to right-front passenger fatalities, and using the list of matching make-models and ranges of model years from Table 1-1, the following fatality reductions are obtained:

Analysis of Matching Make-Models: Overall Fatality Reduction

Chrysler	10	percent
Ford	8	
GM	13	
Imports	3	

In other words, the driver of a Chrysler car with an air bag had 10 percent lower fatality risk than the driver of a Chrysler car not equipped with an air bag, etc. The differences in the preceding estimates are well within the range of the sampling error that exists when the accident data are split four ways. In fact, one of the problems with the analysis is the relatively small number of accident cases in each cell. In comparisons of air bag effectiveness among subgroups of vehicles, it might be desirable to increase the sample, even at the risk of some bias in the overall result. The numbers can be expanded by including **all** model-year 1985-95 cars, not just the matching make-models and limited model years specified in Table 1-1. While it was argued in Section 1.5 that expanding the data set to include many model years could introduce vehicle-age biases into the results, the bias appears to minimal, at least in the estimation of overall air bag effectiveness by the driver vs. right-front passenger analysis method: the lower section of Table C-25 in Appendix C obtains an effectiveness estimate of 10 percent, for all manufacturers combined, with the larger data set; that is identical to the estimate in Table 1-2 based on the matching make-models and limited model years. When effectiveness is computed separately for each manufacturer with the larger data set, the results are:

Analysis of All Make-Models: Overall Fatality Reduction

Chrysler	11	percent
Ford	9	
GM	10	
Imports	9	

These results strongly suggest that effectiveness is likely to be about the same in the four groups, and they create no suspicion that the "differences" observed in the previous table are due to anything other than sampling error.

2.4 Single vs. multivehicle crashes

Frontal single-vehicle crashes frequently involve conditions quite different from the flat-barrier crash tested in FMVSS 208. For example, the object contacted, such as a tree or pole, is often narrow, and the resulting damage pattern may include significant intrusion of structures into the occupant compartment; the off-road excursion prior to impact may throw occupants out of position. That raises a possible concern that air bags could be less effective in single-vehicle than in multivehicle crashes.

Table 2-9 compares the fatality reduction for driver air bags in single-vehicle and multivehicle crashes (detailed analyses may be found in Tables C-7 - C-10 of Appendix C). The analysis based on

TABLE 2-9

FATALITY REDUCTION FOR CAR DRIVER AIR BAGS
BY CRASH TYPE AND IMPACT LOCATION

	Percent Fatality Reduction		
	Analysis Method		
	Compare Driver to Right Front*	Compare Frontal to Nonfrontal*	Average
Single-vehicle crashes			
Purely frontal impacts	22	***26***	24
Partially frontal impacts	- 6	12	3
All crashes	4	***12***	8
Multivehicle crashes			
Purely frontal impacts	***39***	***26***	32.5
Partially frontal impacts	4	6	5
All crashes	***14***	***12***	13

****Statistically significant results are shown in bold italics.***

comparison of drivers to right-front passengers produces more favorable results in the multivehicle crashes, whereas the frontal vs. nonfrontal analysis yields nearly identical effectiveness in single- and multivehicle crashes. That method yields four statistically significant reductions: in purely frontal single-vehicle crashes, in all single-vehicle crashes, in purely frontal multivehicle crashes and in all multivehicle crashes. When the estimates from the two methods are averaged, the fatality reduction in single-vehicle and multivehicle crashes is essentially the same (within sampling error), perhaps leaning toward a slightly better performance in the multivehicle crashes. For example, the fatality reduction is 24 percent in purely frontal single-vehicle crashes and 32.5 percent in multivehicle. The overall fatality reduction is 8 percent in single and 13 percent in multivehicle crashes.

2.5 By occupant age and sex

Intrinsic vulnerability to fatal injury, given exposure to the same crash forces, increases by 2-5 percent for each year that an adult occupant gets older, and it is 30 percent higher for females than for males [8], pp. 22-28; [18], p. 9. Given the substantial differences in occupant responses to impact, it is appropriate to investigate any crashworthiness measure to see if the fatality reduction varies with occupant age and sex. It is especially appropriate with driver air bags, since older drivers and women, if they are of short stature, may sit close to the steering wheel and be in a position to interact with the air bag during its forceful early stages of deployment.

The analysis method that compares fatalities in frontal to nonfrontal crashes may be applied, without change from the procedures in the preceding sections, to any subset of drivers, such as drivers in a particular age group, or male drivers. It is not so simple with the analysis method that compares driver to right-front passenger fatalities. If we want, for example, to calculate fatality reduction for 14-29 year old drivers, is it permissible to include all cases where a 14-29 year old driver was a accompanied by a right-front passenger of **any** age, or is it better to limit the analysis to cases where the driver and the passenger were **both** 14-29 years old? Theoretically, both approaches are valid applications of "double-pair comparison analysis [7]," but, somehow, the latter approach is preferable: the benefit of driver air bags is most easily interpreted if the baseline crashes are those where the driver and passenger are about the same age, and thus about equally at risk.

Table 2-10 summarizes all the analyses of fatality reduction by driver age group. Three large age groups were initially considered: 14-29, 30-55 and 56+. The results for 14-29 and 30-55 are about the same, as will be described below, but the 56+ group shows a drop in effectiveness, suggesting additional study. That group is subdivided into ages 56-69 and 70+, and fatality reduction is calculated separately for those subgroups. The detailed analyses supporting Table 2-10 are Tables C-11 - C-20 of Appendix C.

In purely frontal crashes with a 14-29 year old driver **and** passenger, air bags reduce the driver's fatality risk by a statistically significant 37 percent (see also Table C-11). In partially frontal crashes, the reduction is a nonsignificant 3 percent. The overall reduction for 14-29 year old drivers, by this method, is a nonsignificant 14 percent. The method of comparing frontal to nonfrontal crashes yields statistically significant reductions for 14-29 year olds (see also Table C-13) in purely frontal and in all frontal crashes. The average for the two methods is a 32 percent fatality reduction in purely frontal impacts, 8 percent in partial frontals, and an average of 13.5 percent in all crashes.

TABLE 2-10: FATALITY REDUCTION FOR CAR DRIVER AIR BAGS
BY DRIVER AGE AND IMPACT LOCATION

	Percent Fatality Reduction			
	Analysis Method			
	Compare Driver to Right Front*	**Compare Frontal to Nonfrontal**		
		Matching Make-Models*	**All Make-Models (Adjusted)**	**Average**
Age 14-29				
Purely frontal impacts	***37***	***27***		32
Partially frontal impacts	3	13		8
All crashes	14	***13***		13.5
Age 30-55				
Purely frontal impacts		***35***		35
Partially frontal impacts		13		13
All crashes		***17***		17
Age 56 or older				
Purely frontal impacts	***31***	17		24
Partially frontal impacts	- 11	- 10		- 10.5
All crashes	10	4		7
Age 56-69				
Purely frontal impacts		23	27	25
Partially frontal impacts		- 8	6	- 1
All crashes		8	12	10
Age 70 or older				
Purely frontal impacts		11	11	11
Partially frontal impacts		- 11	- 5	- 8
All crashes		2	1	1.5

****Statistically significant results are shown in bold italics.***

There are not enough accident cases with a 30-55 year old driver **and** right-front passenger for a statistically meaningful analysis; thus only the frontal vs. nonfrontal analysis is used for that age group. The observed fatality reductions are statistically significant, and even slightly higher than the corresponding values for 14-29 year olds (see also Table C-14), reaching 35 percent in purely frontal crashes.

The first two sections of Table 2-10, comprising drivers up to 55 years old, show consistent benefits for air bags: a reduction of 30 percent or more in purely frontal crashes, nonsignificant but consistently positive observed effects in partially frontal crashes, and an overall effect well above the 11 percent average in Chapter 1.

Mixed results are obtained for drivers age 56 or older, as shown in the third section of Table 2-10. When the analysis is based on comparing drivers age 56+ to right-front passengers age 56+ (see also Table C-12), the reduction in purely frontal crashes is a statistically significant 31 percent. It is partly offset, however, by a nonsignificant 11 percent fatality increase in partially frontal crashes. The net effect is a 10 percent reduction. The frontal vs. nonfrontal analysis (Table C-15), based on more than twice as many accident cases, yields less favorable results: a nonsignificant 17 percent reduction in purely frontal impacts, a nonsignificant 10 percent increase in partial frontals, and a net reduction of just 4 percent.

If the fatality reduction for air bags drops off after age 55, it is appropriate to ask if the results get worse as the drivers get older. The last two sections of Table 2-10 consider 56-69 and 70+ year old drivers separately. In these subgroups, there are not enough cases for a meaningful driver vs. right-front passenger analysis, and even the frontal vs. nonfrontal analysis is based on somewhat sparse data, with cell counts sometimes well under 200 (see Tables C-16 and C-17). That analysis is supplemented by another method that permits the use of additional data, although it needs correction for biases.

As explained in Section 1.5, the frontal vs. nonfrontal method was limited to selected make-models equipped with air bags for which there existed matching data of the same make-models without air bags. No more than 3 model years before or after the switch to air bags were included. Any model that got Antilock Brake Systems (ABS) at about the same time as air bags was excluded, since ABS also shifts the fatal-accident distribution to a lower proportion of frontals [16], [20]. If the accident data set is expanded to include **all** 1985-95 cars (except those with 2-point automatic belts), for all model years, regardless of ABS status, the number of cases with air bags doubles, and the number without air bags increases by a factor of ten. Table C-18 computes the fatality "reduction" for air bags with this expanded data set for drivers of all age groups, to investigate the extent of bias in the results. Fatality "reduction" in purely frontal crashes is 33 percent, which is 6 percent above the value in the unbiased frontal-nonfrontal analysis with matching makes and models (Table 2-2). The reduction in partial frontals is 10 percent, 1 percent beyond the unbiased value. The reduction in all frontals is 24 percent, 5 percent above the unbiased value. Fatality reduction in all crashes is 16 percent, 4 percent above the unbiased value in Table 1-3. These observed biases (6, 1, 5 and 4 percent, respectively) are **subtracted** from the results obtained for any subset of this expanded data set to adjust those results and make them comparable to the unbiased estimates.

Thus, for example, in the limited data set with matching make-models, the fatality reduction for air bags for 56-69 year old drivers in purely frontal crashes is 23 percent (see also Table C-16). After adjustment for bias (i.e., subtraction of 6 percent; see Table C-19), the fatality reduction in the expanded data set is 27 percent. The average of the two estimates is 25 percent. There is a 1 percent increase in the partially frontal crashes. The overall fatality reduction averages 10 percent. All of these numbers are still close to the average for drivers of all ages, combined.

The results are less favorable for drivers age 70 or older. The fatality reduction in purely frontal crashes is 11 percent in both data sets. The effect in partially frontal crashes is consistently negative, although not statistically significant. The effect in all crashes is a nonsignificant 2 percent in the limited data set and 1 percent in the expanded set, averaging out to 1.5 percent.

These data, at first glance, suggest that air bags have little **net** benefit for older drivers. An important caveat, however, is that the results on older drivers are based on relatively small samples and are less precise than the estimates for young drivers. Whereas the "best" estimate of overall fatality reduction for drivers age 70 or older is 1.5 percent, the confidence bounds for effectiveness range from -12 to +15 percent. (These confidence bounds are calculated by the same method as in Section 1.5 - i.e., 90 percent confidence bounds.) Thus, while the central tendency in the data suggests that the effect is close to zero, it is possible that air bags could be as beneficial for old as young drivers (but it is also conceivable that air bags could have a negative effect for old drivers.)

Is it possible, at least, to infer that air bags are significantly **less** effective for drivers age 70 or older than for drivers age 55 or younger? CATMOD analyses of 2 x 2 x 2 tabulations of fatalities by crash mode (e.g., purely frontal vs. nonfrontal; or, alternatively, any frontal vs. nonfrontal), driver age (up to 55, 70 or older) and type of occupant protection (driver air bag, no air bag) produce mixed results. With the limited data set of matching make-models, the interaction term air bag x age group falls short of statistical significance ($\chi^2 = 2.35$) when the dependent variable is the proportion of fatalities that are pure frontals. The interaction term also falls short of significance ($\chi^2 = 2.69$) when the dependent variable is the proportion of fatalities that are purely or partially frontal. However, with the extended data set including all make-models in all model years, 1985-95, both of these interaction terms become statistically significant at the .01 level: $\chi^2 = 10.01$ in the analysis of pure frontals and $\chi^2 = 8.45$ in the analysis of all frontals. In other words, with this data set, air bags are significantly less effective for drivers age 70 or older than for drivers age 55 or younger. (Whereas the extended data set produces biased effectiveness estimates, it is not unreasonable to assume that the biases will be about the same for various subgroups of the driver population, and to use this data set, without adjustments, for testing the interaction between driver age and air bag effectiveness.)

If air bags have little **net** benefit for older drivers, it does not necessarily imply that they have no effect at all. It is entirely possible that they do good in some crashes and harm in others, and the harm cancels out the good. Actually, there are three possible ways that air bags could have a zero net effect for older drivers:

(1) All of the fatal lesions for these drivers involve components other than the air bag, such as the A-pillar, header, belt system, noncontact injury, etc. Air bags are irrelevant to these injuries. The people are dying from the same injury sources as they did without air bags.

(2) Some people are dying from lesions involving interaction with the air bag. However, these same people would have died from contacts with other components, such as the steering assembly, if an air bag had not been there. Air bags are causing some fatal lesions, but only to people who would not have survived anyway.

(3) Air bags are causing fatal injuries to some drivers who would have survived the same crash if the car had not been equipped with air bags. But they are also saving the lives of some other drivers who would have died if the car had not been equipped with air bags. The number of new fatalities is equal to the number of lives saved, resulting in a zero net effect.

The FARS data do not provide any information on the injury sources of occupants. Nevertheless, our experience with crash testing and in-depth accident investigation suggest that (1) is the least likely possibility. Similarly, the consistently positive findings in pure frontal crashes and negative in partially frontal crashes, although nonsignificant, also lean in the direction that air bags sometimes do good and sometimes do harm to older drivers. If **either** (2) or (3) is correct, it would imply that current air bags sometimes apply forces that cannot be endured by older drivers.

Given that air bags are less effective for older drivers, one might also expect a lower fatality reduction for female drivers. Table 2-11 (derived from detailed Tables C-21 - C-24 in Appendix C) compares fatality reductions by air bags for male and female drivers. The driver vs. right-front passenger analysis method is not used, since there not so many accident cases in which the driver **and** passenger are of the same gender. Instead, the frontal vs. nonfrontal analysis is applied in two versions: with the limited list of matching make-models; and with all 1985-95 cars, corrected for bias due to ABS, etc. In the matching make-models, the fatality reduction for air bags in purely frontal crashes is statistically significant for both male and female drivers. However, the reduction is slightly, but consistently higher for males than females in every impact type: 28 vs. 25 percent in pure frontals, 12 vs. 2 percent in partial frontals, and 14 vs. 9 percent overall. In the larger data set, after correction for bias, the results are essentially similar, except the observed difference between males and females is smaller in purely frontal crashes, and overall: e.g., 13 vs. 10 percent overall effectiveness. These data could support a hypothesis that air bags are somewhat less effective for women than men, but they are also compatible with the hypothesis that fatality reduction is about equal for men and women: specifically, CATMOD analyses of 2 x 2 x 2 tabulations of fatalities in the limited data set by crash mode, driver's gender and type of occupant protection did not show a statistically significant interaction between gender and air bag effectiveness in purely frontal crashes ($\chi^2 = 0.12$) or in all types of frontal crashes ($\chi^2 = 0.50$).

A final question is whether the combination of age and gender affects fatality reduction, viz., if female drivers age 70 or older, who may combine high vulnerability to impact with short stature, are experiencing problems with air bags. The current data do not reveal this to be the case. In frontal vs. nonfrontal analyses, the results for female drivers age 70 or older are nearly identical to those for males over 70. Neither group, however, experienced a statistically significant fatality reduction; both had overall effects close to zero.

TABLE 2-11

FATALITY REDUCTION FOR CAR DRIVER AIR BAGS
BY DRIVER'S GENDER AND IMPACT LOCATION

	Percent Fatality Reduction		
	Analysis Method: Compare Frontal to Nonfrontal		
	Matching Make-Models*	All Make-Models (Adjusted)	Average
Male drivers			
Purely frontal impacts	***28***	28	28
Partially frontal impacts	12	13	12.5
All crashes	***14***	13	13.5
Female drivers			
Purely frontal impacts	***25***	27	26
Partially frontal impacts	2	5	3.5
All crashes	***9***	10	9.5

****Statistically significant results are shown in bold italics.***

2.6 Passenger air bags and children

Recent in-depth investigations of crashes involving fatalities of child passengers in vehicles equipped with dual air bags revealed a substantial number of cases in which the fatal lesions appear to have involved interaction of the child, or a rear-facing child safety seat, with the passenger air bag: a NHTSA press release cited 19 such cases cumulative through May 1996 [28], while an article in *USA Today*, listed 22 cases cumulative through early July 1996 [14]. Fourteen of the crashes occurred before the end of 1995, and the remainder in calendar year 1996. The principal concern raised by the in-depth investigations as well as earlier crash tests and engineering analyses is that children are shorter and lighter than adults. That makes unbelted or incorrectly belted children prone to being tossed forward during panic braking or minor impacts prior to the deployment of the air bag. Some children, even correctly belted ones, may sit far forward in their seat (e.g., to look out the window or adjust the radio), close to the air bag, during normal vehicle operations. A parallel concern is that rear-facing child safety seats place infants close to the air bag when they are placed in the right-front seat of a vehicle. Either way, the child's head, neck and thorax can be in the path of the deploying air bag during the forceful early stages of the deployment. An additional worry is that the youngest children are intrinsically more vulnerable to injury than teenagers or young adults.

It is appropriate to perform statistical analyses of the limited available FARS data involving vehicles with dual air bags that had children occupying the right-front seat. The objective of the statistical analyses is not to find out if children are experiencing problems with current air bags: the in-depth accident investigations have already established that they do. All the statistical analyses can add is quantitative information about the risk of children in cars equipped with dual air bags relative to the risk of children in cars without air bags; the analyses may be helpful in identifying groups of crashes where fatality risk with air bags is higher than expected. The FARS data in this analysis are complete only through early 1996 and exclude the most recent child passenger fatalities that have been investigated by NHTSA. On the other hand, the FARS data are not limited to cases of children who received fatal lesions from contacts with air bags; the 38 FARS records of child passenger fatalities, age 0-12, who had been occupying the right-front seat of a car equipped with dual air bags includes children who received fatal injuries from sources unrelated to air bags - e.g., in nonfrontal crashes.

The statistical analysis addresses these questions, to the extent possible given the available data:

(1) Do children in the right-front seat have a higher fatality risk with dual air bags?
(2) At what ages is there an increase in fatality risk?
(3) In what types of crashes does fatality risk increase?
(4) How large is the increase? Is it statistically significant?

Table 2-12 addresses the first two questions. It computes the overall fatality reduction by passenger air bags for all right-front passengers from infants up to the age shown in the stub column, based on comparisons of right-front and driver fatalities in crashes of cars with dual air bags, and cars with driver air-bags only. Drivers of all ages are included in the analyses. The data are not limited to the make-models and model-year ranges of Table 1-7, but compare **all** cars with dual air bags and 3-point [manual or automatic] belts to all cars with driver air bags and 3-point belts. The extended data set is used to maximize the number of accident cases in the analysis; extending the data set may introduce biases on the order of 5 percent, as discussed above, but such biases are trivial in the context of the

TABLE 2-12 - CAR PASSENGERS, **BY AGE OF THE CHILD PASSENGER**: EFFECTIVENESS OF PASSENGER AIR BAGS BASED ON REDUCTION OF RIGHT FRONT PASSENGER FATALITIES RELATIVE TO DRIVER FATALITIES

(both seats occupied; all cars with driver or dual air bags and 3-point belts)

Cumulative Occupant Fatality Counts

	Cars with Dual Air Bags		Cars with Driver Air Bags		**Cumulative** % Reduction for Passenger Air Bags
	Rt Front	Drivers	Rt Front	Drivers	
Passenger Age Group	A	B	C	D	(1 - AD/BC) %
0	4	1	7	7	- 300
0-1	6	2	11	11	- 200
0-2	8	3	17	19	- 198
0-3	9	3	26	26	- 200
0-4	17	10	30	30	- 70
0-5	23	12	36	42	- 124
0-6	29	15	40	52	- 151
0-7	31	20	44	59	- 108
0-8	32	22	48	70	- 112
0-9	33	23	52	78	- 115
0-10	34	24	54	88	- 131
0-11	35	28	59	96	- 103
0-12	38	30	74	110	- 88
0-13	40	34	86	126	- 72
0-14	45	50	109	142	- 17
0-15	52	66	153	189	3
All ages	759	721	2198	1843	12

large effects for air bags shown in Table 2-12.

In the cars with dual air bags, Table 2-12 shows that, cumulative up to age 13, the number of child passenger fatalities exceeds the fatalities among the drivers who accompanied those passengers. For example, there were 34 fatalities to children age 0-10 (column A) and only 24 of the drivers accompanying them were fatally injured (column B). But in the cars with a driver air bag and no passenger bag, child passenger fatalities (C) initially are about the same as driver fatalities (D), and with the inclusion of children age 8-13, who are at substantially lower risk than adults, C gets steadily smaller than D - e.g., 54 passenger fatalities age 0-10 and 88 deaths among the drivers of those cars. Thus, the observed fatality reduction for passenger air bags is consistently negative for child passengers. Moreover, after the fluctuation in the first few years, as might be expected with the small numbers of accident cases, the effect settles down to about a 120 percent increase and stays there up through age 10. When the 11-13-year-olds are added to the data, the results gradually turn in a more favorable direction for air bags. The inclusion of 14-year-olds dramatically improves the results for air bags, and the inclusion of 15-year olds makes the results cross over to a net benefit. Finally, when right-front passengers of all ages are included in the analysis, the net fatality reduction for passenger bags is 12 percent. The table shows that right-front passengers age 16 or older are far more numerous than child passengers; as a consequence, the positive results for adult and teenage passengers statistically eclipse the negative effects for child passengers.

Thus, Table 2-12 shows that the fatality increase with passenger air bags persists from birth up through age 10. Positive results for air bags appear to begin in the 11-13 age range and become quite strong at ages 14 and 15. Of course, given the small number of accident cases, Table 2-12 cannot be expected to provide definitive answers on what age children experience increased fatality risk with air bags, but the numbers appear to be consistent with NHTSA's position that problems might persist up through age 12. At age 13, a large proportion of teenagers are as tall or taller than a small adult female, and they have legs long enough to contact the instrument panel or firewall and prevent the head and torso from being thrown too far forward during pre-crash braking. At age 11 and 12, some children are already as tall as small adults, but many are not. Up to age 10, most children are shorter than a small adult female, and they are at risk of being thrown forward prior to air bag deployment, or they may be sitting far forward in the seat even during normal vehicle operations.

Table 2-13 helps to explain what types of crashes result in higher fatality risk for children with passenger air bags. Fatality reduction is calculated for child passengers age 0-12 by the driver vs. right-front method for various subsets of the data used in Table 2-12. The first section of Table 2-13 recapitulates the "0-12" row of Table 2-12, and shows an 88 percent fatality increase for passenger air bags that is statistically significant at the .05 level ($\chi^2 = 4.93$).

When the analysis is limited to frontal and partially frontal crashes, the negative effect gets stronger: a 112 percent increase. When it is further limited to purely frontal crashes, the effect escalates to a 186 percent increase. Finally, when the data are further limited to purely frontal impacts **with another vehicle**, the increase grows to 236 percent. Each of these three increases is statistically significant at the .05 level ($\chi^2 = 4.30$, 5.07 and 5.03, respectively). It is noteworthy that 16 of the 38 child passenger fatalities with air bags are in purely frontal multivehicle impacts, but just 17 of 74 fatalities without the air bags. Again, this result makes intuitive sense. Multivehicle crashes, unlike

TABLE 2-13 - CHILD PASSENGERS AGE 0-12, **BY IMPACT LOCATION**:
EFFECTIVENESS OF PASSENGER AIR BAGS BASED ON REDUCTION OF
RIGHT FRONT PASSENGER FATALITIES RELATIVE TO DRIVER FATALITIES

(both seats occupied; all cars with driver or dual air bags and 3-point belts)

	Right Front Child Fatalities	**Driver Fatalities**	**Risk Ratio**	**Percent Reduction**
		IN ALL CRASHES		
Cars w. driver air bags	74	110	.672	
Cars w. dual air bags	38	30	1.267	- 88
		(statistically significant difference: $\chi^2 = 4.93$)		
		IN ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)		
Cars w. driver air bags	43	63	.683	
Cars w. dual air bags	26	18	1.444	- 112
		(statistically significant difference: $\chi^2 = 4.30$)		
		IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)		
Cars w. driver air bags	20	35	.571	
Cars w. dual air bags	18	11	1.636	- 186
		(statistically significant difference: $\chi^2 = 5.07$)		
		IN PURELY FRONTAL MULTIVEHICLE CRASHES (12:00 principal impact; most harmful event is not a rollover; 2 or more vehicles in the crash)		
Cars w. driver air bags	17	25	.680	
Cars w. dual air bags	16	7	2.286	- 236
		(statistically significant difference: $\chi^2 = 5.03$)		

run-off-road fixed-object impacts, are likely to involve a reasonably alert driver who may slam on the brakes in a final attempt to avoid hitting the other vehicle. In a purely frontal impact, that could result in the child being thrown toward the air bag just before it deploys.

For a "best estimate" of the actual effect of passenger air bags and an assessment of its statistical significance, the analysis method of Table 2-14 is recommended for use with the current, rather sparse accident data. One problem with Tables 2-12 and 2-13 is that the "control group" data set of child passengers in cars with driver air bags is itself rather small, and it may be contributing to the sampling error. A much larger data set of child passengers may be obtained by considering 1985-95 cars with 3-point belts and no air bags at all. The first section of Table 2-14 shows that these 0-12 year old right-front passengers have experienced 1046 fatalities to date, while 1184 of the accompanying drivers were killed in crashes. Since those drivers were not protected by air bags, they are not directly comparable to the drivers in the cars with dual air bags. However, a principal finding of Chapter 1 was that driver air bags reduce fatality risk by 11 percent. Thus, if those cars had been equipped with driver air bags, the 1184 driver fatalities would have decreased by 11 percent, to 1054, and there still would have been the same 1046 child passenger fatalities, a risk ratio of .992 for the children. In the cars with dual air bags, the risk ratio was 1.267. The estimated fatality reduction for passenger bags is -28 percent, and it is not statistically significant ($\chi^2 = 0.97$).

Similarly, in purely frontal multivehicle crashes, there were 268 child passenger fatalities and 364 driver fatalities in the cars without air bags. If these cars had been equipped with driver air bags, we may assume the driver fatalities would have decreased by 30 percent, to 255 (see Table 2-7). The risk ratio for child passengers is 1.051 without air bags and 2.286 with air bags. The estimated fatality reduction is -117 percent, and it falls short of statistical significance ($\chi^2 = 2.96$).

In other words, the best estimate with the currently available data is that child passenger fatalities could be increasing with air bags, substantially so in purely frontal crashes. The findings by the preferred analysis method are not statistically significant (Table 2-14), although the findings by another method are statistically significant at the .05 level (Table 2-13). These statistical analyses, in the absence of evidence from any other source, would ordinarily not be sufficient to conclude definitively that child passenger fatalities are increasing with air bags, let alone to determine a specific numerical value for the increase. However, in this case, there is already substantial evidence from in-depth accident investigations that child passengers can have fatal interactions with air bags, and the statistical findings of this report are consistent with the concerns raised by the in-depth investigations. At this time, the fleet of vehicles equipped with passenger bags is expanding rapidly, and the analyses shown here can and should be updated with extensive new data during the next 12 months.

In summary, in-depth investigations revealed 14 cases during 1986-95 in which fatal lesions appear to have involved interaction of a child, or a rear-facing child safety seat, with the passenger air bag. It was estimated in Section 1.8 that passenger air bags saved the lives of 88 passengers age 13 or older during that time period. The number of lives saved far exceeded the child passenger fatalities primarily because the overwhelming majority of right front passengers, even during 1986-95, were adults or teenagers, not children. The Department of Transportation and other organizations are now striving to inform **all** parents that the safest place for children is the back seat. Parents can generally eliminate the air bag risk by insisting that their children ride buckled up in the back seat.

TABLE 2-14 - CHILD PASSENGERS AGE 0-12, **BEST ESTIMATES**
EFFECTIVENESS OF PASSENGER AIR BAGS BASED ON REDUCTION OF
RIGHT FRONT PASSENGER FATALITIES RELATIVE TO DRIVER FATALITIES

CARS WITH DUAL AIR BAGS VS. CARS WITH NO AIR BAGS

(both seats occupied; all cars with dual air bags and 3-point belts vs. cars with 3-point belts only)

	Right Front Child Fatalities	Driver Fatalities	Risk Ratio	Percent Reduction
IN ALL CRASHES				
Cars with belts only	1046	1184 * *1054* §	.992	
Cars w. dual air bags	38	30	1.267	- 28
(not a statistically significant difference: $\chi^2 = 0.97$)				
IN PURELY FRONTAL MULTIVEHICLE CRASHES (12:00 principal impact; most harmful event is not a rollover; 2 or more vehicles in the crash)				
Cars with belts only	268	364 * *255* ‡	1.051	
Cars w. dual air bags	16	7	2.286	- 117
(not a statistically significant difference: $\chi^2 = 2.96$)				

* Actual fatalities
§ Fatalities diminished by 11 percent to simulate risk with driver air bags
‡ Fatalities diminished by 30 percent to simulate risk with driver air bags

CHAPTER 3

AIR BAG EFFECTIVENESS FOR BELTED VS. UNRESTRAINED CAR DRIVERS

3.1 What does it matter?

The overall "as used" fatality reduction by air bags for all drivers of passenger cars - belted and unrestrained drivers combined - is approximately 11 percent. Thus, the two "when used" fatality reductions, as defined in Section 1.4 - (1) air bag effectiveness for the unrestrained driver, and (2) air bag effectiveness for the belted driver (i.e., the incremental effectiveness of an air bag plus belts over just wearing the belts) - have to "average" out to 11 percent. However, there are many combinations that could average to that number. For example, if both "when used" reductions were exactly 11 percent, they would of course average to 11 percent. But it is also conceivable that one of the reductions is much higher than 11 percent while the other is zero or even negative - and they average out to 11 percent. Why are we interested in the two "when used" reductions if, no matter what they are, we already know they will average to 11 percent? Three important reasons come to mind.

First, the "when used" reductions can resolve whether 11 percent is a stable or unstable measure of overall fatality reduction. If incremental air bag effectiveness is about the same for the belted and the unrestrained driver, the 11 percent overall effect will stay about the same in the future, even if belt use were to change a lot. But if, for example, air bags were only effective for the unrestrained occupant, and belt use were to increase to over 90 percent, the overall benefits of air bags would dwindle, and the 11 percent estimate, although valid today, would have little meaning in the future.

Second, a policy issue is at stake. If the accident data were to show, for example, that air bags only benefitted unbelted occupants, and that they did not benefit, or in some cases even harmed belt users, the majority of the population that buckles up might question the need and expense of air bags. (A few years ago, a similar issue was raised with some automatic belts that were perceived as offering less protection for more money to people who already used manual belts.) On the other hand, if the accident data show that air bags have significant benefits for belted **and** unrestrained drivers, the issue becomes moot.

Third, any knowledge about the effectiveness of air bags for specific subgroups of the population - belt users and nonusers - would be helpful for engineers developing more effective systems.

The analysis would be straightforward if it were possible to rely entirely on the accuracy of belt use reporting in fatal crashes. In that case, it would be possible to do separate analyses of fatality reduction by air bags for the belted and the unbelted occupants, just like the analyses in Chapter 2 for old vs. young drivers, males vs. females, etc. However, the consensus is that FARS does not necessarily contain accurate information about the belt use of crash survivors, especially in recent years [24]. Basically, police who investigate fatal crashes are usually not eye-witnesses to the crash itself. They arrive several minutes later, at which point survivors may be out of the car. Police may have to rely on the survivor's statement of belt use when no other evidence is available; survivors do not necessarily wish to report that they were unrestrained, especially if belt use is required by law.

It is widely assumed that FARS reports belt use quite accurately for fatalities, who may not have been moved between the crash and the arrival of the police. However, even for fatalities, evidence of belt use is not always directly observable several minutes after the crash, and there are factors that make it hard to ascertain belt use accurately, or that could bias its reporting. Thus, the less the data analysis relies on belt use reporting in FARS, especially for survivors, and the more it relies on directly observable phenomena, the less uncertainty there might be in the results. Three methods for analyzing the data are used here: the first relies directly on FARS belt use reporting for fatalities and survivors, the second on fatalities only, and the third not directly on either.

3.2 Estimates based on FARS-reported belt use

Notwithstanding the caveats about belt use reporting on FARS, it's at least worth the effort to see what happens when fatality reduction for air bags is calculated for belt users and nonusers - as reported in FARS. The analysis method is the comparison of driver and right-front passenger fatalities in the cars, as defined in Section 1.5. However, not all available accident cases will be included: we will analyze only the cars in which the driver and right-front passenger were **both belted** according to FARS (to estimate fatality reduction by air bags for belted drivers) or in which they were **both unbelted** (to estimate the reduction for unrestrained drivers). There are two reasons for choosing only the cases where the control group (right-front passengers) has the same belt use as the drivers. (1) As in the analyses of effectiveness by occupant age (Section 2.5), the benefit of air bags is most easily interpreted if the baseline crashes (in cars without air bags) are those where the driver and passenger have the same belt use, and thus about equally at risk. (2) There may be intuitive reasons to believe that when FARS reports both people as belted, or both as unbelted, it's more likely to be accurate than when it reports one occupant as belted (the survivor in almost all cases) and the other as unbelted (the fatality in almost all cases), and there is a suspicion that the report of belt use or nonuse could have been influenced by the outcome of the crash.

Table 3-1 estimates the fatality reduction for driver air bags in crashes where both front-seat occupants were **belted** according to FARS (REST_USE or MAN_REST = 1, 2, 3, 8, or 13). The analysis is limited to the make-models, and model year ranges listed in Table 1-1. In the cars without air bags, there were 264 driver fatalities and 308 right-front passenger fatalities in purely frontal crashes, a risk ratio of .857. In other words, a belted driver is slightly less at risk than a belted passenger. But with driver air bags, there were only 130 driver fatalities (with air bag and belts) vs. 197 right-front passenger fatalities (with belts only), a risk factor of .660. That is a 23 percent fatality reduction by air bags for belted drivers, and it falls short of statistical significance ($\chi^2 = 3.46$). Table 3-1 also shows close to a zero effect for air bags in partially frontal crashes. In all crashes, the fatality reduction is 5 percent, and it is not statistically significant ($\chi^2 = 0.39$).

In an effort to include more accident cases, Table 3-1X extends the analysis to a comparison of all model year 1985-95 cars with driver air bags and 3-point belts vs. all 1985-95 cars with 3-point belts only - i.e., not just the makes, models and model years in Table 1-1. That increases the sample of cars with air bags by about 40 percent and cars with belts only by a factor of 5. Fatality reductions stay about the same: the reduction in purely frontal crashes is 21 percent, and, with this larger sample, the reduction is statistically significant at the .05 level ($\chi^2 = 5.64$). The effect in partially frontal crashes is again close to zero, and the overall reduction is a nonsignificant 7 percent. (Unlike the frontal vs.

TABLE 3-1 - **BELTED DRIVERS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

DRIVER AND RIGHT-FRONT SEATS BOTH OCCUPIED BY
PEOPLE WEARING BELTS ACCORDING TO FARS

LIMITED DATA SET: MAKE-MODELS THAT HAD MANUAL OR AUTOMATIC 3-POINT BELTS AND ADDED DRIVER AIR BAGS WITHOUT CHANGING THE BELT SYSTEM

	Driver Fatalities	Right Front Fatalities	Risk Ratio	Percent Reduction
IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Cars with belts only	264	308	.857	
Cars w. driver air bags	130	197	.660	23
(not a statistically significant difference: $\chi^2 = 3.46$)				
IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Cars with belts only	216	232	.931	
Cars w. driver air bags	137	146	.938	- 1
(not a statistically significant difference: $\chi^2 = 0.03$)				
IN ALL CRASHES				
Cars with belts only	844	1001	.843	
Cars w. driver air bags	509	633	.804	5
(not a statistically significant difference: $\chi^2 = 0.39$)				

TABLE 3-1X - **BELTED DRIVERS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

DRIVER AND RIGHT-FRONT SEATS BOTH OCCUPIED BY
PEOPLE WEARING BELTS ACCORDING TO FARS

EXTENDED DATA SET: ALL 1985-95 CARS WITH DRIVER AIR BAGS AND 3-POINT BELTS
VS. ALL 1985-95 CARS WITH 3-POINT BELTS ONLY

	Driver Fatalities	**Right Front Fatalities**	**Risk Ratio**	**Percent Reduction**
IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Cars with belts only	1505	1680	.896	
Cars w. driver air bags	188	267	.704	21
(statistically significant difference: $\chi^2 = 5.64$)				
IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Cars with belts only	1208	1229	.983	
Cars w. driver air bags	196	201	.975	1
(not a statistically significant difference: $\chi^2 = 0.05$)				
IN ALL CRASHES				
Cars with belts only	4760	5390	.883	
Cars w. driver air bags	722	879	.821	7
(not a statistically significant difference: $\chi^2 = 1.80$)				

nonfrontal analysis, where adding in the models that got ABS at the same time as air bags biases the results and necessitates an adjustment, as shown in Table C-18 of Appendix C, the additional accident cases here do not inflict a systematic bias in favor of air bags. Table C-25 shows that, with the extended sample, the fatality reduction by air bags for **all** occupants, regardless of their belt use, is 29 percent in pure frontals, 4 percent in partial frontals and 10 percent in all crashes. Those are essentially the same results, give or take sampling error, as with the limited sample: 34 percent in pure frontals, -2 percent in partial frontals and 10 percent in all crashes - see Tables 1-2 and 2-1.)

Table 3-2 estimates the fatality reduction for driver air bags in crashes where both front-seat occupants were **unbelted** according to FARS (REST_USE or MAN_REST = 0), using the limited sample of make-models. The fatality reduction in purely frontal crashes is 34 percent, and it is statistically significant at the .01 level ($\chi^2 = 7.92$). In partially frontal crashes, fatality risk increases by a nonsignificant 15 percent ($\chi^2 = 0.94$). The net effect in all crashes is a nonsignificant 1 percent reduction. When the accident sample is extended to all 1985-95 cars with 3-point belts, in Table 3-2X, the fatality reduction for air bags in purely frontal crashes is a statistically significant 32 percent ($\chi^2 = 11.61$, $p < .01$). The observed effect in partially frontal crashes is still negative, but here it's just -5 percent. The net effect in all crashes is a nonsignificant 4 percent reduction.

These analyses of drivers vs. right-front passengers strongly suggest that driver air bags are beneficial for both belted and unbelted drivers in purely frontal crashes, as evidenced by statistically significant reductions in three of the four tables. They also imply that the effect of air bags for belted drivers is not too different from their effect for unbelted drivers: in the purely frontal crashes, the observed reduction is slightly higher for unbelted drivers, but in partial frontals and overall, belted drivers have slightly higher observed reductions. However, these analyses have a flaw that makes them unreliable for assessing the overall effect of air bags: the fatality reduction in all crashes for belted drivers (5 percent in Tables 3-1 and 7 percent in Table 3-1X) and unbelted drivers (1 percent in Table 3-2 and 4 percent in Table 3-2X) do **not** average out to 11 percent, the overall, "as used" fatality reduction. Evidently, air bags have a higher observed effect in the accident cases not used here: those where one of the occupants was reported as belted and the other as unrestrained, or where one or both occupants had unknown belt use. It is not clear why that happens; it might be tied to errors in belt use reporting, but not necessarily.

The other analysis method of this report - comparison of fatalities in frontal and nonfrontal crashes, as documented in Section 1.5 - employs only those accident cases in which a driver was a fatality. Crashes where the driver survived never enter the analysis. Joksch has pointed out that this analysis can be performed for just those driver fatalities that are reported as belted [unbelted] on FARS, and since surviving drivers are not involved in the analysis, it relies only on FARS reports of belt use for fatalities, not survivors [17]. If reporting of belt use is accurate in FARS for fatally injured people, the frontal vs. nonfrontal method ought to provide unbiased "when used" estimates of fatality reduction by air bags.

Table 3-3 computes the fatality reduction by air bags for **belted** drivers, based on the frontal vs. nonfrontal method. It is limited to the "balanced" sample of makes, models and model years listed in Table 1-1, and it excludes models that got Antilock Brake Systems at about the same time as air bags. The top section of Table 3-3 shows that there were 603 belted purely frontal driver fatalities

TABLE 3-2 - **UNBELTED DRIVERS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

DRIVER AND RIGHT-FRONT SEATS BOTH OCCUPIED BY
PEOPLE NOT WEARING BELTS ACCORDING TO FARS

LIMITED DATA SET: MAKE-MODELS THAT HAD MANUAL OR AUTOMATIC 3-POINT BELTS
AND ADDED DRIVER AIR BAGS WITHOUT CHANGING THE BELT SYSTEM

	Driver Fatalities	Right Front Fatalities	Risk Ratio	Percent Reduction
IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Cars with belts only	359	355	1.011	
Cars w. driver air bags	99	149	.664	34
(statistically significant difference: $\chi^2 = 7.92$)				
IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Cars with belts only	295	314	.939	
Cars w. driver air bags	151	140	1.079	- 15
(not a statistically significant difference: $\chi^2 = 0.94$)				
IN ALL CRASHES				
Cars with belts only	1008	1031	.978	
Cars w. driver air bags	451	468	.963	1
(not a statistically significant difference: $\chi^2 = 0.03$)				

TABLE 3-2X - **UNBELTED DRIVERS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

DRIVER AND RIGHT-FRONT SEATS BOTH OCCUPIED BY
PEOPLE NOT WEARING BELTS ACCORDING TO FARS

EXTENDED DATA SET: ALL 1985-95 CARS WITH DRIVER AIR BAGS AND 3-POINT BELTS
VS. ALL 1985-95 CARS WITH 3-POINT BELTS ONLY

	Driver Fatalities	**Right Front Fatalities**	**Risk Ratio**	**Percent Reduction**
		IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)		
Cars with belts only	2654	2673	.993	
Cars w. driver air bags	137	203	.675	32
		(statistically significant difference: $\chi^2 = 11.61$)		
		IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)		
Cars with belts only	2159	2112	1.022	
Cars w. driver air bags	207	193	1.073	- 5
		(not a statistically significant difference: $\chi^2 = 0.21$)		
		IN ALL CRASHES		
Cars with belts only	7483	7533	.993	
Cars w. driver air bags	619	651	.951	4
		(not a statistically significant difference: $\chi^2 = 0.56$)		

TABLE 3-3 - **BELTED DRIVERS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS WHO WORE BELTS ACCORDING TO FARS

LIMITED DATA SET: MAKE-MODELS THAT HAD MANUAL OR AUTOMATIC 3-POINT BELTS AND ADDED DRIVER AIR BAGS WITHOUT CHANGING THE BELT SYSTEM, EXCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	678	503	
Purely frontal fatalities	603	351	22
(statistically significant difference: $\chi^2 = 7.39$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	678	503	
Partially frontal fatalities	465	290	16
(not a statistically significant difference: $\chi^2 = 3.33$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	678	503	
Frontal fatalities	1068	641	19
(statistically significant difference: $\chi^2 = 7.55$)			

Fatality reduction for driver air bags in all types of crashes: 12 percent

and 678 belted nonfrontal driver fatalities in the cars without air bags. But in cars equipped with air bags, there were only 351 belted purely frontal driver fatalities as opposed to 503 belted nonfrontals. The relative reduction of purely frontal fatalities by air bags, for belted drivers

1 - [(351/503) / (603/678)] = **22 percent**

is statistically significant at the .01 level (χ^2 = 7.39). In partially frontal crashes, the reduction is a nonsignificant 16 percent (χ^2 = 3.33). In all types of crashes, this method estimates a statistically significant 12 percent fatality reduction for the driver who has an air bag and wears belts, relative to the driver who wears belts but has no air bag (χ^2 = 7.55, $p < .01$).

In an effort to include more accident cases, Table 3-3X extends the analysis to all model year 1985-95 cars with driver air bags and 3-point belts vs. all 1985-95 cars with 3-point belts only, including models that got ABS at about the same time as air bags. That nearly doubles the sample of cars with air bags and expands the sample of belt-only cars almost tenfold. However, as explained in Section 2.5, it introduces biases in favor of air bags, and requires adjustment of the results. After adjustment of the results, the fatality reductions are slightly lower than in Table 3-3: the reduction is 19 percent in purely frontal crashes, 9 percent in partially frontal crashes, and a net 7 percent in all types of crashes.

Tables 3-4 and 3-4X perform corresponding analyses for the fatally injured drivers who were **unbelted** according to FARS. In the limited accident data set, the fatality reduction by air bags is an exceptionally strong, statistically significant 34 percent in purely frontal crashes (χ^2 = 26.82). The observed reduction in partially frontal crashes is a nonsignificant 4 percent. The fatality reduction in all types of crashes is 14 percent, and it is statistically significant (χ^2 = 11.26). The estimates for the extended data set (Table 3-4X) are virtually identical, after adjustment for bias: reductions of 34 percent in purely frontal crashes, 7 percent in partially frontal crashes, and 14 percent in all crashes.

The analyses of frontals vs. nonfrontals likewise strongly suggest that driver air bags are beneficial for both belted and unbelted drivers in purely frontal crashes: in both cases the reductions are statistically significant at the .01 level (in Tables 3-3 and 3-4). However, these analyses, unlike the driver vs. right-front computations, appear to suggest that air bags are somewhat more effective for the unbelted than the belted driver in purely frontal crashes, and also in all frontal crashes. Are the differences in the observed effectiveness estimates statistically significant? CATMOD analyses of 2 x 2 x 2 tabulations of fatalities by crash mode (e.g., purely frontal vs. nonfrontal; or, alternatively, any frontal vs. nonfrontal), belt use and type of occupant protection (driver air bag, no air bag) produce mixed results. With the limited data set of matching make-models, the interaction term air bag x belt use is nonsignificant (χ^2 = 1.99) when the dependent variable is the proportion of fatalities that are pure frontals, and also when the dependent variable is the proportion of fatalities that are frontal (χ^2 = 0.02). However, with the extended data set including all make-models in all model years, the interaction term becomes statistically significant at the .01 level (χ^2 = 10.32) in the analysis of pure frontals, but not in the analysis of all frontals (χ^2 = 2.72). Although the observed effectiveness of air bags is higher for the unbelted occupant in all four of the analyses, it is significantly higher in only one of them. In other words, the CATMOD analyses confirm our eyeball interpretation of the results: they lean in the direction of higher air bag effectiveness for the unbelted occupant, but not quite definitively so.

TABLE 3-3X- **BELTED DRIVERS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS
WHO WORE BELTS ACCORDING TO FARS

EXTENDED DATA SET: ALL 1985-95 CARS WITH DRIVER AIR BAGS AND 3-POINT BELTS
VS. ALL 1985-95 CARS WITH 3-POINT BELTS ONLY,
INCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

			Frontal Fat. Red. for Air Bags (%)	
	Cars with Belts Only	**Cars with Driver Air Bags**	**Observed**	**Adjusted**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Nonfrontal fatalities	6437	994		
Purely frontal fatalities	5873	683	25	19
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Nonfrontal fatalities	6437	994		
Partially frontal fatalities	4224	588	10	9
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)				
Nonfrontal fatalities	6,437	994		
Frontal fatalities	10,097	1271	18	13
Fatality reduction for driver air bags in all types of crashes:			**11**	7

TABLE 3-4 - **UNBELTED DRIVERS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS
WHO WERE UNRESTRAINED ACCORDING TO FARS

LIMITED DATA SET: MAKE-MODELS THAT HAD MANUAL OR AUTOMATIC 3-POINT BELTS AND ADDED DRIVER AIR BAGS WITHOUT CHANGING THE BELT SYSTEM, EXCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	971	516	
Purely frontal fatalities	1136	400	34
(statistically significant difference: $\chi^2 = 26.82$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	971	516	
Partially frontal fatalities	917	469	4
(not a statistically significant difference: $\chi^2 = 0.24$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	971	516	
Frontal fatalities	2053	869	20
(statistically significant difference: $\chi^2 = 11.26$)			

Fatality reduction for driver air bags in all types of crashes: 14 percent

TABLE 3-4X- **UNBELTED DRIVERS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS
WHO WERE UNRESTRAINED ACCORDING TO FARS

EXTENDED DATA SET: ALL 1985-95 CARS WITH DRIVER AIR BAGS AND 3-POINT BELTS
VS. ALL 1985-95 CARS WITH 3-POINT BELTS ONLY,
INCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

			Frontal Fat. Red. for Air Bags (%)	
	Cars with Belts Only	**Cars with Driver Air Bags**	**Observed**	**Adjusted**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Nonfrontal fatalities	9,740	985		
Purely frontal fatalities	12,192	734	40	34
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Nonfrontal fatalities	9,740	985		
Partially frontal fatalities	9,225	860	8	7
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)				
Nonfrontal fatalities	9,740	985		
Frontal fatalities	21,417	1594	26	21
Fatality reduction for driver air bags in all types of crashes:			**18**	**14**

Whereas, in the frontal vs. nonfrontal analyses, the average of the overall effects for belted and unbelted drivers comes out close to 11 percent, there is still a problem that raises a question about the data: when the same method is applied to the FARS cases of driver fatalities with **unknown** belt use, as shown in Tables C-26 and C-27, all of the observed fatality reductions for air bags are close to zero or negative (although nonsignificant), even in purely frontal crashes. It is not clear why that happens; it might conceivably indicate a problem in belt use reporting, but not necessarily.

Table 3-5 summarizes all of the preceding results based on FARS-reported belt use. The fatality reduction for air bags is analyzed four times, in each of three crash modes (purely frontal, partially frontal, all crashes) for belted drivers (top section) and unbelted drivers (lower section). The estimates from the four analyses are averaged. But they are **weighted** averages. Since the two frontal vs. nonfrontal analyses rely only on belt use reporting for fatally injured occupants, they are more dependable than the two driver vs. right-front passenger analyses, so they are given double weight in the computation of the average.

In purely frontal crashes, Table 3-5 indicates a weighted average of 21 percent fatality reduction for belted drivers and nearly 34 percent for unbelted drivers; moreover, in all four individual analyses, the observed reduction is higher for the unbelted drivers. Approximate 90 percent confidence bounds (i.e., two-sided $\alpha = .05$) for the fatality reductions in purely frontal crashes may be developed from the entries in the top sections of Tables 3-3 and 3-4, using the same method as in Section 2.1. The confidence bounds of the fatality reduction for belted drivers are 9 to 33 percent. The confidence bounds for the unbelted drivers are 25 to 42 percent.

The higher effectiveness of air bags for unbelted drivers in purely frontal crashes is somewhat offset in the partially frontal crashes, where the average reduction is 8.3 percent for the belted drivers and close to zero for the unbelted; here, in each of the four individual analyses, the observed result is better for the belted drivers. For all types of crashes, the weighted average fatality reduction by air bags is 8.3 percent for belted drivers and 10.2 percent for unbelted drivers. These two estimates do not average to 11 percent and, for that reason, should not be considered the "best" estimates of effectiveness. The concluding section of this chapter (Section 3.4) will further develop estimates of overall effectiveness, and their confidence bounds.

3.3 Analyses that do not rely on FARS belt use reporting

If air bags are more effective for the unbelted than the belted occupant, we ought to see the highest air bag effectiveness in the States with the lowest belt use. Conversely, if we fail to see higher air bag effectiveness in the States with the lowest belt use, it might raise doubts about the earlier finding that air bags are more effective for unrestrained occupants. The analyses of this section identify a group of drivers (by State, etc.) that has high belt use, and another group that has low belt use, and they compare the effectiveness of air bags in the two groups. But it is not known whether any **individual** driver in the first group was, in fact, wearing belts, or any individual in the second was, in fact, unrestrained. For that reason, these analyses are not intended as a proxy for the previous section, in which drivers were grouped by their actual [as-reported] belt use. Instead, their purpose is to test and, hopefully, support the findings in Table 3-5. The reason for performing the analyses is the uncertainty, of some researchers, about the accuracy of belt-use reporting on FARS. Potential

TABLE 3-5: FATALITY REDUCTION BY CAR DRIVER AIR BAGS
FOR BELTED VS. UNBELTED DRIVERS, BY IMPACT LOCATION

SUMMARY OF ESTIMATES BASED ON FARS-REPORTED BELT USE

	Percent Fatality Reduction by Air Bags — Analysis Method				
	Compare Driver to Right Front		Compare Frontal to Nonfrontal		
	Matching Make-Models*	All Make-Models*	Matching Make-Models*	All Make-Models (Adjusted)	Weighted[§] Average
For belted drivers					
Purely frontal impacts	23	***21***	***22***	19	21
Partially frontal impacts	- 1	1	16	9	8.3
All crashes	5	7	***12***	7	8.3
For unbelted drivers					
Purely frontal impacts	***34***	***32***	***34***	34	33.7
Partially frontal impacts	- 15	- 5	4	7	0.3
All crashes	1	4	***14***	14	10.2

****Statistically significant results are shown in bold italics.***
[§]Estimates based on frontal vs. nonfrontal analyses are given double weight.

skepticism about results based directly on belt-use reporting in FARS may be allayed if those results are confirmed by analyses that do not rely on FARS-reported belt use.

Even without the belt-use variable on FARS, it is possible to recognize some drivers who were likely to have been belted, and others who were less likely. Three factors that can be ascertained from other FARS variables have a strong association with belt use:

- **State/calendar year** - belt use by the general motoring population is much higher in a State with a widely-enforced belt use law than in a State without a buckle-up law. It ranged from 22 percent in Mississippi during 1990 to 85 percent in Hawaii during 1991.

- **Sobriety** - belt use is substantially higher for sober drivers than for drunk drivers.

- **Vehicle age** - belt use decreases steadily as a car gets older [4], p. 23.

The **expected** probability of belt use will be assessed for each car driver in 1989-96 FARS, by a model based on the State and the calendar year of the accident, the driver's sobriety, and the age of the car. For example, the model might predict in a certain crash situation (State, calendar year, sobriety, vehicle age) that 75 percent of drivers involved in that crash situation would be belted, and 25 percent unbelted. The various fatal crashes on 1989-96 FARS will be divided into four class intervals of expected belt use: 68-100, 57-68, 40-57 and 0-40. The fatality reduction for air bags will be calculated in each of the four subsets by the frontal vs. nonfrontal analysis method. If the four effectiveness estimates show a trend of increasing [decreasing] effectiveness as expected belt use declines, it would imply that air bags are more [less] effective for unrestrained than belted drivers. *But if the four estimates do not show a trend, they would be consistent with the hypothesis that air bags are about equally effective for belted and unbelted drivers.*

The **logistic** model is well-suited for calibrating expected belt use, since there tend to be linear relationships between the various factors discussed above and the log-odds of belt use (i.e., the logarithm of the ratio of belt users to nonusers). The starting point for the model is the aggregate belt use of fatally injured drivers of cars less than 3 years old, equipped with **manual** 3-point belts (with or without air bags, but no automatic belts), as reported on FARS, excluding cases with unknown belt use, by calendar year:

Belt Use of Fatally Injured Car Drivers

Calendar Year	Belt Use (%)	Log-Odds
1989	31.7	-.768
1990	34.4	-.642
1991	39.8	-.413
1992	45.3	-.190
1993	47.7	-.094
1994-96	48.9	-.044

The next step is to infer belt use in **potentially fatal crashes** - i.e., crashes that were fatal to the driver plus crashes that were survived by a belted driver, but would have been fatal if belts had not been used [24]. Since a driver wearing a manual 3-point belt has 45 percent lower fatality risk than an unrestrained driver under similar crash circumstances [13], p. IV-2, 55 belted fatalities on FARS presumably represent 100 drivers who were belted and involved in a potentially fatal crash. The log-odds of belt use in potentially fatal crashes is simply the log-odds for fatals plus 0.598 = log(1/.55).

Belt use declines as a car gets older. The reasons for the decline are not known; it is possible that people who drive older cars are generally less safety-conscious than those who drive new cars. Whatever the reason, the relationship between vehicle age and the **log-odds** of belt use by drivers who were fatally injured, or who were in potentially fatal crashes, is almost perfectly linear for cars age 0-10 years. A General Linear Model [27] of 1989-95 FARS data, celled by calendar year and vehicle age and weighted by the number of cases, suggests that the log-odds for cars less than a year old is 0.095 higher than the average log-odds for cars 0-2 years old, in any given calendar year. For each year that a car gets older, the log-odds decrease by 0.0787. R^2 for this regression is .75.

The effect of sobriety on the log-odds of belt use is quite consistent throughout 1989-95. For fatally injured drivers that had not been drinking, according to FARS (DRINKING = 0), the log-odds of belt use was 0.391 higher than the average for all drivers. For driver fatalities that had been drinking according to FARS (DRINKING = 1), the log-odds of belt use was 0.976 **lower** than average. For all other driver fatalities - those whose alcohol consumption was unknown or not reported - the log-odds of belt use was 0.009 lower than average.

State-to-State variations in belt use are documented in observational surveys of the general motoring population, conducted by the States themselves. The surveys are based on eye-witness observations of representative samples of drivers not involved in crashes. Appendix D shows belt use in each State, by calendar year from 1990 to 1994, and also the population-weighted national averages of the values from the 50 States and the District of Columbia. For the general population (not in potentially fatal crashes), belt use in the United States rose from 53.09 percent in 1990 to 66.96 percent in 1994, and its log-odds rose from +0.1238 in 1990 to +0.7064 in 1994. A belt-use factor for any particular State and calendar year is computed by taking the log-odds of belt use for that State and year, and subtracting from it the national log-odds for that year. For example, observed belt use was 42 percent in Alabama in 1990, and its log-odds were -0.3228. Since the national log-odds for 1990 was +0.1238, the Alabama-1990 factor is -0.4466. Thus, in potentially fatal crashes, the log-odds of belt use by a driver in Alabama during 1990 is .4466 lower than the log-odds for the average driver nationwide. These State-year factors can be defined directly from Appendix D for 1990-94. To expand the data available for analysis, it is assumed that the 1990 factors are also reasonably accurate for 1989, and the 1994 factors for 1995-96.

The expected belt use for any driver on FARS may be calculated by adding the various factors, and then converting the log-odds back to a percentage. For a sober driver of a new car in Hawaii during 1995, the factors are:

- .044	Calendar year 1995 log-odds of belt use for fatals
+ .598	Belt use in potentially fatal crashes
+ .095	Car less than 1 year old
+ .391	Sober driver
+ .952	Hawaii 1994/95 belt use vs. U.S. average
+ 1.992	

and the expected belt use is 88 percent [exp 1.992 / (1 + exp 1.992)]. On the other hand, for a drunk driver of a 1985 car in Mississippi during 1990, the factors are:

- .642	Calendar year 1990 log-odds of belt use for fatals
+ .598	Belt use in potentially fatal crashes
- .299	Car 5 years old
- .976	Drinking driver
- 1.389	Mississippi 1990 belt use vs. U.S. average
- 2.708	

and the expected belt use is 6 percent [exp -2.708 / (1 + exp -2.708)]. The values of expected belt use in potentially fatal crashes for the 1989-96 FARS cases fill up the range of possibilities between these rather extreme values of 6 and 88 percent.

The 1989-96 FARS cases of fatally injured drivers, in cars equipped with driver air bags and 3-point belts or just with 3-point belts, are subdivided into four ranges of expected belt use: 68-100, 57-68, 40-57 and 0-40. The boundaries of the ranges were selected so that each group has about the same number of air-bag equipped cases; all four groups contain plenty of cars without air bags, but it is the air-bag equipped sample size that drives the statistical analysis. The **average** values of expected belt use in the four ranges are 75, 62, 49 and 29 percent, respectively. In other words, we can be quite sure that the first group contains a high proportion of belt users, and the last group a low one, without having to worry that drivers have been placed into the wrong groups as a consequence of possible errors of belt-use reporting on FARS.

Table 3-6 summarizes the analyses of fatality reduction by air bags in each of the four groups, based on the comparison of fatalities in frontal vs. nonfrontal crashes. The top section of Table 3-6 considers drivers with the **highest** expected belt use, and the bottom section the lowest to simplify comparison with Table 3-5, which addresses belted drivers in the top section and unbelted in the lower section. The detailed analyses may be found in Tables C-28 - C-35 of Appendix C. For example, Table C-28 is limited to vehicle cases of the specific makes, models and model years defined in Table 1-1, and it analyzes drivers with expected belt use over 68 percent. The fatality reduction by driver air bags in purely frontal crashes is 31 percent for these drivers, and it is statistically significant at the .01 level (χ^2 = 7.97). The observed effect of driver air bags in partially frontal crashes is a nonsignificant 21 percent increase. The net effect in all types of crashes is a nonsignificant 8 percent reduction. These numbers, 31, -21 and 8, are shown in the first column of the upper section of Table 3-6.

TABLE 3-6: FATALITY REDUCTION FOR CAR DRIVER AIR BAGS
BY EXPECTED BELT USE AND IMPACT LOCATION

EXPECTED BELT USE IS BASED ON THE DRIVER'S
STATE, ALCOHOL STATUS, VEHICLE AGE AND THE CALENDAR YEAR

	Percent Fatality Reduction by Air Bags		
	Analysis Method: Compare Frontal to Nonfrontal		
	Matching Make-Models*	All Make-Models (Adjusted)	Average
Expected belt use over 68 percent (average: 75 percent)			
Purely frontal impacts	***31***	20	25.5
Partially frontal impacts	- 21	- 9	- 15
All crashes	8	4	6
Expected belt use 57-68 percent (average: 62 percent)			
Purely frontal impacts	17	21	19
Partially frontal impacts	- 2	- 4	- 3
All crashes	5	5	5
Expected belt use 40-57 percent (average: 49 percent)			
Purely frontal impacts	***40***	33	36.5
Partially frontal impacts	18	8	13
All crashes	***20***	13	16.5
Expected belt use 0-40 percent (average: 29 percent)			
Purely frontal impacts	29	28	23.5
Partially frontal impacts	13	15	14
All crashes	11	14	12.5

****Statistically significant results are shown in bold italics.***

Table C-29 extends the analysis of drivers with expected belt use over 68 percent to all 1985-95 cars with 3-point belts and, possibly, driver air bags, including models that got ABS at the same time as air bags. After adjustment for the biases that are introduced by including cars that got ABS with air bags, the fatality reductions for air bags are 20 percent in pure frontals, -9 percent in partial frontals and 4 percent in all crashes. These are shown in the second column of the top section of Table 3-6. The averages of the fatality reductions in the limited and extended (adjusted) analyses are shown in the last column of Table 3-6: 25.5 percent reduction in pure frontals, 15 percent increase in partial frontals, 6 percent reduction in all crashes for drivers with over 68 percent expected belt use.

The three lower sections of Table 3-6 present corresponding results for drivers less likely to have buckled up. At first glance, Table 3-6 shows a probable, but not obvious trend toward higher fatality reduction by air bags for successively less belted groups of drivers. In every crash mode, the average effectiveness of air bags for the two groups with low expected belt use, combined, is higher than the corresponding average for the two high-belt-use groups, combined. In most cases, the effectiveness estimates for each of the two low-belt-use groups are higher than the corresponding estimates for either high-belt-use group. Nevertheless, the trend is not monotone or linear. In general, the drivers with 57-68 percent expected belt use have the worst results for air bags (e.g., only 5 percent observed fatality reduction in all types of crashes), while the drivers with 40-57 percent belt use tend to have the best results (36.5 percent reduction in pure frontals and 16.5 percent in all crashes). The two extreme belt use groups (over 68 and under 40 percent) have results that are mostly between those for the two middle groups. Also, none of the four groups yields results that are grossly different, considering the sample sizes, from the fatality reductions for all drivers combined: 27 percent in pure frontals, 6 percent in partial frontals and 11 percent in all crashes (Tables 2-2 and 1-3).

The search for trends is simplified by looking at just the average belt use in each of the four groups, and the average values of fatality reduction in each crash mode:

	Fatality Reduction by Air Bags (%)		
Belt Use (%)	Pure Frontals	Partial Frontals	All Crashes
75	25.5	- 15	6
62	19	- 3	5
49	36.5	13	16.5
29	23.5	14	12.5

The fatality reductions in pure frontals, 25.5, 19, 36.5, 23.5 do not show a trend, but the average for the two low-belt-use groups is somewhat higher than the average for the two high-belt-use groups, consistent with the differences seen in the analyses based on FARS belt-use reporting (Table 3-5). The observed effects in partial frontals show a monotone, but not linear pattern of more positive results as belt use decreases. The only problem is that the analyses based on FARS-reported belt use, as documented in Table 3-5, leaned toward the opposite result. When the two sets of results are viewed together, it is really not possible to draw any conclusion on partial frontals. The four reductions in crashes of all types, 6, 5, 16.5 and 12.5 percent do not have a monotone trend, but they still suggest, unmistakably, that air bag effectiveness is higher in the low belt use groups.

CATMOD analyses of 2 x 4 x 2 tabulations of fatalities by crash mode (e.g., purely frontal vs. nonfrontal; or, alternatively, any frontal vs. nonfrontal), expected-belt-use group (4 groups, but expected belt use is treated as a linear variable with values .75, .62, .49 and .29) and type of occupant protection (driver air bag, no air bag) produce mixed results. With the limited data set of matching make-models, the interaction term air bag x expected belt use is close to zero when the dependent variable is the proportion of fatalities that are pure frontals; when the dependent variable is the proportion of fatalities that are frontal, the interaction term is in the expected direction (i.e., air bags become less effective in reducing fatalities as expected belt use increases) but not statistically significant ($\chi^2 = 1.16$). However, with the extended data set including all make-models in all model years, both of these interaction terms are statistically significant and in the expected direction ($\chi^2 = 4.90$ and 8.99, respectively).

3.4 Summary

The two principal findings of the analyses of air-bag effectiveness based on actual belt use as reported in FARS were that (1) air bags significantly reduce fatality risk for belted as well as unbelted drivers, as evidenced by a multitude of statistically significant results; (2) there is substantial, but not quite conclusive evidence that the effectiveness of air bags is higher for the unbelted than for the belted driver. The analyses of air bag effectiveness for four expected-belt-use groups strongly support both of those findings.

Section 3.2 presented "when used" effectiveness estimates for air bags in **purely frontal** crashes: air bags reduced the fatality risk of an unbelted driver by nearly 34 percent; the fatality risk of a belted driver with air bags was 21 percent lower than the fatality risk of a belted driver without air bags. Now, let us try to develop corresponding "when used" estimates for **all** types of crashes. As stated at the beginning of this chapter, the two estimates must average to 11 percent, the "as used" effectiveness of air bags for all drivers (and, for all practical purposes, it will be satisfactory if the simple arithmetic average of the two estimates is 11 percent, since about half of driver fatalities are currently belted, and half unbelted).

It is unlikely that both "when used" reductions are 11 percent: there is simply too much evidence that air bags are more effective for unbelted drivers than for belted drivers. The analyses of Section 3.2 furnished point estimates of 10.2 percent for unbelted drivers and 8.3 percent for belted drivers. If both estimates are revised upwards until they average to 11 percent (and rounded to whole numbers), they suggest a 12 percent reduction for unbelted drivers and a 10 percent reduction for belted drivers. However, those numbers still seem too close together. The results for purely frontal crashes suggest that the effect of air bags is about 1½ times as large for unbelted drivers as for belted drivers, and the results for the expected-belt-use groups also suggest that air bags are perceptibly more effective for the unbelted driver.

When all of the results are taken into account, the best point estimates would appear to be **a 13 percent fatality reduction by air bags for unbelted drivers and a 9 percent incremental fatality reduction by air bags for belted drivers**. These point estimates, however, are difficult to interpret without confidence bounds. Approximate 90 percent confidence bounds (i.e., two-sided $\alpha = .05$) may be developed from the entries in the lowest sections of Tables 3-3 and 3-4, using the same method as in Section 1.5. The confidence bounds of the overall fatality reduction for unbelted drivers are 7 to 19 percent. The confidence bounds of the incremental fatality reduction by air bags for belted drivers are 3 to 15 percent. In other words, there is considerable overlap between the two confidence intervals. Furthermore, both point estimates of "when-used" effectiveness (13 and 9 percent) are within the current confidence bounds for "as used" effectiveness (7 to 15 percent; see Section 1.5).

Based on these findings, a preliminary prediction can be made that the current "as used" fatality reduction for air bags, 11 percent, is unlikely to change radically if safety belt use increases substantially in the future, because the "when used" reductions for belted and unbelted occupants are both positive, and probably neither is too far away from 11 percent. The difference between the two "when used" estimates is within the current noise range of the "as used" estimate. Even if belt use were to rise above 90 percent, air bags would continue to provide effective supplemental protection according to the current data.

REFERENCES

[1] *Automotive News Market Data Book Issue*. Annual Publication. Detroit: Crain Automotive Group, Inc.

[2] *Code of Federal Regulations*, Title 49. Washington: General Printing Office, 1994.

[3] *Consumer Information: Automatic Crash Protection for Passenger Cars*. Annual Publication, 1987-93. Washington: National Highway Traffic Safety Administration, Office of Public and Consumer Affairs.

[4] Datta, Tapan K., and Guzek, Paul. *Restraint System Use in 19 U. S. Cities, 1989 Annual Report*. Report No. DOT HS 807 595. Washington: National Highway Traffic Safety Administration, [1990].

[5] *Effect of Car Size on Fatality and Injury Risk*. Washington: National Highway Traffic Safety Administration, [1991].

[6] *Evaluation of the Effectiveness of Occupant Protection: Federal Motor Vehicle Safety Standard 208, Interim Report*. Technical Report No. DOT HS 807 843. Washington: National Highway Traffic Safety Administration, [1992].

[7] Evans, Leonard. "Double Pair Comparison - A New Method to Determine How Occupant Characteristics Affect Fatality Risk in Traffic Crashes." *Accident Analysis an Prevention* 18 (June 1986).

[8] ______. *Traffic Safety and the Driver*. New York: Van Nostrand Reinhold, 1991.

[9] *FARS 1995 Coding and Validation Manual*. Washington: National Highway Traffic Safety Administration, National Center for Statistics and Analysis [1995].

[10] *Federal Register* 49 (17 July 1984): 28962.

[11] *Federal Register* 55 (17 January 1990): 1586.

[12] *Federal Register* 58 (4 October 1993): 51735.

[13] *Final Regulatory Impact Analysis, Amendment to Federal Motor Vehicle Safety Standard 208, Passenger Car Front Seat Occupant Protection*. Report No. DOT HS 806 572. Washington: National Highway Traffic Safety Administration, [1984].

[14] Healy, James R., and O'Donnell, Jayne. "Deadly Air Bags." *USA Today*, July 8, 1996.

[15] Hertz, Ellen; Hilton, Judith; and Johnson, Delmas M. *An Analysis of the Crash Experience of Light Trucks Equipped with Antilock Brake Systems*. Technical Report No. DOT HS 808 278. Washington: National Highway Traffic Safety Administration, [1995].

[16] _____. *An Analysis of the Crash Experience of Passenger Cars Equipped with Antilock Brake Systems*. Technical Report No. DOT HS 808 279. Washington: National Highway Traffic Safety Administration, [1995].

[17] Joksch, Hans C. *Airbag Fatalities Approximation for Passenger Car Fleet*. To appear in 1996.

[18] Kahane, Charles J. *Correlation of NCAP Performance with Fatality Risk in Actual Head-On Collisions*. Technical Report No. DOT HS 808 061. Washington: National Highway Traffic Safety Administration, [1994].

[19] _______. "Fatality Reduction by Automatic Occupant Protection in the United States" *Proceedings of the Fourteenth International Technical Conference on the Enhancement of Safety in Vehicles*. Washington: National Highway Traffic Safety Administration, [1994].

[20] ________. *Preliminary Evaluation of the Effectiveness of Antilock Brake Systems for Passenger Cars*. Technical Report No. DOT HS 808 206. Washington: National Highway Traffic Safety Administration, [1994].

[21] *National Vehicle Population Profile*. Annual Publication. Detroit: R. L. Polk.

[22] NHTSA Docket 01-22-N11B (Manufacturers' explanations of VIN as required by 49 CFR 565.5).

[23] *NHTSA Hails Safety Features in Model Year 1994 Passenger Cars and Light Trucks and Vans*. Press Release No. NHTSA 38-93. Washington: U. S. Department of Transportation, Office of the Assistant Secretary for Public Affairs, [1993].

[24] Partyka, Susan C. *Lives Saved by Seat Belts from 1983 through 1987*. NHTSA Technical Report No. DOT HS 807 324. Washington: National Highway Traffic Safety Administration, [1988].

[25] *Passenger Vehicle Identification Manual*. Annual Publication. Palos Hills, IL: National Insurance Crime Bureau.

[26] Perkins, David D.; Cynecki, Michael J.; and Goryl, Michael E. *Restraint System Usage in the Traffic Population, 1983 Annual Report*. Report No. DOT HS 806 582. Washington: National Highway Traffic Safety Administration, [1984].

[27] *SAS User's Guide: Statistics, Version 5 Edition*. Cary, NC: SAS Institute, Inc., 1985.

[28] *Secretary Peña Announces Government/Industry Coalition for Air Bag Safety.* Press Release No. NHTSA 24-96. Washington: U. S. Department of Transportation, Office of the Assistant Secretary for Public Affairs, [1996].

[29] Zador, Paul L., and Ciccone, Michael A. *Driver Fatalities in Frontal Impacts: Comparisons between Cars with Air Bags and Manual Belts.* Insurance Special Report No. A-38. Arlington, VA: Insurance Institute for Highway Safety, [1991].

APPENDIX A

PASSENGER CARS
TYPES OF OCCUPANT PROTECTION BY MAKE-MODEL AND YEAR

EXPLANATION OF CODES

.	make-model was not sold in this model year
0	manual 3-point belts for driver and right-front (RF) passenger
9	occupant protection system unknown - or - 2 or more types offered that year, but VIN does not specify which type is on a particular vehicle
303	motorized 2-point belts without disconnect + manual lap belts for driver and RF
404	motorized 2-point belts with disconnect + manual lap belts for driver and RF
505	nonmotorized 3-point [automatic] belts for driver and RF
606	nonmotorized 2-point belts + manual lap belts for driver and RF
707	nonmotorized 2-point belts for driver and RF (no lap belts, knee bolster only)
1000	driver air bag + manual 3-point belts for driver and RF
1003	air bag + manual 3-point belt for the driver, motorized 2-point belt without disconnect + manual lap belt for the RF
1004	air bag + manual 3-point belt for the driver, motorized 2-point belt with disconnect + manual lap belt for the RF
1006	air bag + manual 3-point belt for the driver, nonmotorized 2-point belt + manual lap belt for the RF
1010	dual air bags + manual 3-point belts for driver and RF
1303	driver air bag + motorized 2-point belts without disconnect + manual lap belts for driver and RF
1313	dual air bag + motorized 2-point belts without disconnect + manual lap belts for driver and RF
1404	driver air bag + motorized 2-point belts with disconnect + manual lap belts for driver and RF
1505	driver air bag + nonmotorized 3-point [automatic] belts for driver and RF
1606	driver air bag + nonmotorized 2-point belts + manual lap belts for driver and RF

Note: If two or more types of occupant protection were offered in the same year, and the VIN can be used to identify which type is on a particular vehicle, the first type is shown on the first line, the second type on the second line, etc. Codes marked with a "?" are not used in the analyses.

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
111 AMC Eagle											
109 AMC Eagle	0	0	0	0	.	.	.	.	.	.	.
112 AMC SX4											
110 AMC SX4/Kammback	0	0	.	.	.	.	.	.	.	.	.
614 Aspen/Volare 4 door											
610 Chrysler 5th Avenue	0	0	0	0	1000	.	.	.	.	.	.
				1000		.	.	.	.	.	.
707 Dodge Diplomat	0	0	0	0	1000	.	.	.	.	.	.
				1000		.	.	.	.	.	.
904 Plymouth Gran Fury	0	0	0	0	1000	.	.	.	.	.	.
				1000		.	.	.	.	.	.
615 Omni/Horizon 4 door											
708 Dodge Omni 4 door	0	0	0	0	0	1000	.	.	.	.	.
908 Plymouth Horizon 4 dr	0	0	0	0	0	1000	.	.	.	.	.
616 Omni/Horizon 2 door											
708 Dodge Omni 2 door	0	0	0	.	.	.	.	.	.	.	.
908 Plymouth Horizon 2 dr	0	0	0	.	.	.	.	.	.	.	.
618 Aries/Reliant K											
616 Chrysler LeBaron (except GTS)	0	0	0	0	0	.	.	.	.	.	.
			606	606	1000						
				1000							
				1606							
616 Chrysler LeBaron coupe	.	.	.	.	.	1000	1000	1000	1000	1010	.
616 Chrysler LeBaron convertible	.	.	.	.	.	.	.	.	.	.	1010
711 Dodge Aries	0	0	0	0	0	.	.	.	.	.	.
714 Dodge 600 2 door	0	0	.	.	.	.	.	.	.	.	.
911 Plymouth Reliant	0	0	0	0	0	.	.	.	.	.	.
619 Chrysler E-Class											
614 Chrysler E-Class/New Yorker	0	0	0	0	.	.	.	.	.	.	.
616 Chrysler LeBaron GTS	0	0	0	0	0	.	.	.	.	.	.
714 Dodge 600 4 door	0	0	0	0	.	.	.	.	.	.	.
716 Dodge Lancer	0	0	0	0	0	.	.	.	.	.	.
907 Plymouth Caravelle	0	0	0	0	.	.	.	.	.	.	.
620 Daytona/Sundance											
615 Chrysler Laser	0	0	0	.	.	.	.	.	.	.	.
715 Dodge Daytona	0	0	0	0	1000	1000	1000	1000	1000	.	.
			606	606							
				1000							
				1606							
717 Dodge Shadow	.	.	0	0	0	1000	1000	1000	1000	1004	.
				404	404						
917 Plymouth Sundance	.	.	0	0	0	1000	1000	1000	1000	1004	.
				404	404						
621 Dodge Dynasty											
618 Chrysler New Yorker C	.	.	.	0	0	1000	1000	1000	1000	.	.
718 Dodge Dynasty	.	.	.	0	0	1000	1000	1000	1000	.	.

Car Group Make/Model	85	86	87	88	89	90	91	92	93	94	95
622 Plymouth Acclaim											
616 Chrysler LeBaron sedan	.	.	.	.	.	1000	1000	1000	1000	1004	.
719 Dodge Spirit	.	.	.	.	0	1000	1000	1000	1000	1004	1004
919 Plymouth Acclaim	.	.	.	.	0	1000	1000	1000	1000	1004	1004
623 Chrysler Imperial 109											
620 Chrysler 5th Ave/Imperial	.	.	.	.	.	1000	1000	1000	1000	.	.
624 Dodge Viper											
713 Dodge Viper	.	.	.	.	.	.	.	505	505	505	505
625 Chrysler LH cars											
641 Chrysler Concorde	.	.	.	.	.	.	.	.	1010	1010	1010
642 Chrysler LHS/New Yorker	.	.	.	.	.	.	.	.	.	1010	1010
650 Chrysler Concorde/LHS/New Yorker	.	.	.	.	.	.	.	.	.	.	1010
741 Dodge Intrepid	.	.	.	.	.	.	.	.	1010	1010	1010
1041 Eagle Vision	.	.	.	.	.	.	.	.	1010	1010	1010
626 Chrysler Cirrus/Stratus											
644 Chrysler Cirrus	.	.	.	.	.	.	.	.	.	.	1010
743 Dodge Stratus	.	.	.	.	.	.	.	.	.	.	1010
627 Chrysler Neon											
720 Dodge Neon	.	.	.	.	.	.	.	.	.	.	1010
920 Plymouth Neon	.	.	.	.	.	.	.	.	.	.	1010
1226 Fairmont/Zephyr											
1206 Ford LTD	0	0	.	.	.	.	.	.	.	.	.
1406 Mercury Marquis	0	0	.	.	.	.	.	.	.	.	.
1227 Ford Mustang 100											
1203 Ford Mustang	0	0	0	0	0	1000	1000	1000	1000	.	.
1403 Mercury Capri	0	0	.	.	.	.	.	.	.	.	.
1228 Crown Vic/Grand Marquis											
1216 Ford Crown Victoria	0	0	0	0	0	1000	1000	1000 1010	1000 1010	1010	1010
1416 Mercury Grand Marquis	0	0	0	0	0	1000	1000	1000 1010	1010	1010	1010
1230 Lincoln Town Car											
1301 Lincoln Town Car	0	0	0	0	0	1000 1010	1000 1010	1010	1010	1010	1010
1231 Ford Escort											
1213 Ford Escort	0	0	0 303	9 303	303	303	.	.	.	.	.
1214 Ford EXP	0	0	0	0	.	.	.	.	.	.	.
1413 Mercury Lynx	0	0	0 303	.	.	.	.	.	.	.	.
1232 Lincoln Mark7											
1302 Lincoln Mark7	0	0	0	0	0	1000	1000	1000	.	.	.
1305 Lincoln Continental	0	0	0	.	.	.	.	.	.	.	.

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
1233 Ford Thunderbird 104											
1204 Ford Thunderbird	0	0	0	0	.	.	.	.	.	.	.
1404 Mercury Cougar	0	0	0	0	.	.	.	.	.	.	.
1234 Ford Tempo											
1215 Ford Tempo	0	0	0 1000	303 1000	303 1000	303 1000	303 1000	303 1000	303 1000	303 1003	.
1415 Mercury Topaz	0	0	0 1000	303 1000	303 1000	303 1000	303 1000	303 1000	303 1000	303 1003	
1235 Ford Taurus											
1217 Ford Taurus	.	0	0	0	0	1000	1000	1000 1010	1000 1010	1010	1010
1417 Mercury Sable	.	0	0	0	0	1000	1000	1000 1010	1010	1010	1010
1236 Lincoln Continental 109											
1305 Lincoln Continental	.	.	.	0	1000 1010	1000 1010	1000 1010	1010	1010	1010	1010
1237 Ford Thunderbird 113											
1204 Ford Thunderbird	.	.	.	.	303	303	303	303	303	1010	1010
1302 Lincoln Mark8	.	.	.	.	.	.	.	.	1010	1010	1010
1404 Mercury Cougar	.	.	.	.	303	303	303	303	303	1010	1010
1238 Ford Mustang 101.3											
1203 Ford Mustang	.	.	.	.	.	.	.	.	.	1010	1010
1239 Ford Contour											
1235 Ford Contour	.	.	.	.	.	.	.	.	.	.	1010
1437 Mercury Mystique	.	.	.	.	.	.	.	.	.	.	1010
1838 Chevrolet Chevette 94.3											
2013 Chevrolet Chevette 2 dr	0	0	0	.	.	.	.	.	.	.	.
2213 Pontiac T1000 2 dr	0	0	0	.	.	.	.	.	.	.	.
1839 GM full-sized sedan 116											
1802 Buick LeSabre sedan	0	.	.	.	.	.	.	.	.	.	.
1804 Buick Roadmaster sedan	.	.	.	.	.	.	.	1000	1000	1010	1010
2002 Chevrolet Caprice sedan	0	0	0	0	0	505	1000	1000	1000	1010	1010
2102 Olds Delta 88 sedan	0	0	.	.	.	.	.	.	.	.	.
2202 Pontiac Parisienne	0	0	0	0	0	.	.	.	.	.	.
1840 GM full-sized wagon 116											
1802 Buick Estate Wagon	0	0	0	0	0	505	1000	.	.	.	.
1804 Buick Roadmaster wagon	.	.	.	.	.	.	.	1000	1000	1010	1010
2002 Chevrolet Caprice wagon	0	0	0	0	0	505	1000	1000	1000	1010	1010
2102 Olds Custom Cruiser	0	0	0	0	0	505	1000	1000	1000	.	.
2202 Pontiac Safari	0	0	0	0	0	.	.	.	.	.	.
1842 Cadillac DeVille 121.5											
1903 Cadillac Fleetwood Brougham	0	0	0	0	0	505	505	505	1000 1010	.	.
1903 Cadillac Fleetwood	.	.	.	.	.	.	.	.	.	1010	1010

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
1843 Chevrolet Chevette 97.3											
2013 Chevrolet Chevette 4 dr	0	0	0	.	.	.	.	.	.	.	.
2213 Pontiac T1000 4 dr	0	0	0	.	.	.	.	.	.	.	.
1844 GM Intermediates 108.1											
1801 Buick Regal 4 door	0	.	.	.	.	.	.	.	.	.	.
2101 Olds Cutlass 4 door	0	.	.	.	.	.	.	.	.	.	.
2202 Pontiac Bonneville 4 dr	0	0	.	.	.	.	.	.	.	.	.
1845 GM Sporty Intermediates 108.1											
1810 Buick Regal 2 door	0	0	0	.	.	.	.	.	.	.	.
2010 Chevrolet Monte Carlo	0	0	0	0	.	.	.	.	.	.	.
2101 Olds Cutlass 2 door	0	0	0	0	.	.	.	.	.	.	.
2202 Pontiac Bonneville 2 dr	0	0	.	.	.	.	.	.	.	.	.
2210 Pontiac Grand Prix	0	0	0	.	.	.	.	.	.	.	.
1846 GM Luxury Sports 114											
1805 Buick Riviera	0	.	.	.	.	.	.	.	.	.	.
1905 Cadillac Eldorado	0	.	.	.	.	.	.	.	.	.	.
1914 Cadillac Seville	0	.	.	.	.	.	.	.	.	.	.
2105 Oldsmobile Toronado	0	.	.	.	.	.	.	.	.	.	.
1847 GM Compact X cars											
1815 Buick Skylark	0	.	.	.	.	.	.	.	.	.	.
2015 Chevrolet Citation	0	.	.	.	.	.	.	.	.	.	.
1848 GM Compact J cars											
1816 Buick Skyhawk	0	0	0	0	0	.	.	.	.	.	.
1916 Cadillac Cimarron	0	0	0	0	.	.	.	.	.	.	.
2016 Chevrolet Cavalier	0	0	0	0	0	505	505	505	505	505	.
2116 Olds Firenza	0	0	0	0	.	.	.	.	.	.	.
2216 Pontiac Sunbird	0	0	0	0	0	505	505	505	505	505	.
1849 Chevrolet Camaro F 101											
2009 Chevrolet Camaro	0	0	0	0	0	1000	1000	1000	1010	1010	1010
2209 Pontiac Firebird	0	0	0	0	0	1000	1000	1000	1010	1010	1010
1850 GM Mid-sized A 104.9											
1817 Buick Century	0	0	0	0	0	505	505	505	505 1505	1505	1505
2017 Chevrolet Celebrity	0	0	0	0	0	505	.	.	.	.	.
2117 Olds Ciera	0	0	0	0	0	505	505	505	505 1505	1505	1505
2217 Pontiac 6000	0	0	0	0	0	505	505	.	.	.	.
1851 Chevrolet Corvette Y 96.2											
2004 Chevrolet Corvette	0	0	0	0	0	1000	1000	1000	1000	1010	1010

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
1852 GM Luxury C and Full-sized H 110.8											
1802 Buick LeSabre	.	0	0	505	505	505	505	1000	1000	1010	1010
			505								
1803 Buick Electra	0	0	0	0	505	505	1000	1000	1000	1010	1010
1903 Cadillac DeVille	0	0	0	0	0	.	.	.	.	.	.
					1000						
1903 Cad DeVille coupe	.	.	.	.	.	1000	1000	1000	1000	.	.
									1010		
2102 Olds Delta 88	.	0	0	505	505	505	505	1000	1000	1010	1010
	.	0	505	1000	1000	1000	1000				
2103 Olds 98	0	0	0	0	505	505	1000	1000	1000	1010	1010
					1000	1000					
2202 Pontiac Bonneville	.	.	0	505	505	505	505	1000	1000	1010	1010
	.	.	505					1010	1010		
1853 Pontiac Fiero P											
2205 Pontiac Fiero	0	0	0	0	.	.	.	.	.	.	.
1854 Pontiac Grand Am N 103.4											
1818 Buick Somerset/Skylark	0	0	0	505	505	505	505	505	505	1505	1505
			505								
2118 Olds Calais	0	0	0	505	505	505	505	.	.	.	.
			505								
2121 Olds Achieva	.	.	.	.	.	.	.	505	505	1505	1505
2218 Pontiac Grand Am	0	0	0	505	505	505	505	505	505	1505	1505
			505								
1855 GM luxury sports cars E and Cadillac Seville K 108											
1805 Buick Riviera	.	0	0	0	0	1000	1000	1000	1000	.	.
1905 Cadillac Eldorado	.	0	0	0	0	1000	1000	1000	1010	1010	1010
1914 Cadillac Seville	.	0	0	0	0	1000	1000	.	.	.	.
2105 Oldsmobile Toronado	.	0	0	0	0	1000	1000	1000	.	.	.
1856 Chevrolet Corsica/Beretta L											
2019 Chevrolet Corsica	.	.	0	0	505	505	1000	1000	1000	1505	1505
2019 Chevrolet Beretta	.	.	0	0	505	505	1000	1000	1000	1505	1505
				505							
1857 Cadillac Allante V											
1909 Cadillac Allante	.	.	0	0	0	1000	1000	1000	1000	.	.
1858 Buick Reatta EC											
1821 Buick Reatta	.	.	.	0	0	1000	1000	.	.	.	.
1859 GM Mid-sized W 107.5											
1820 Buick Regal	.	.	.	505	505	505	505	505	505	1505	1010
2020 Chevrolet Lumina	.	.	.	.	.	505	505	505	505	505	1010
2036 Chevrolet Monte Carlo	.	.	.	.	.	.	.	.	.	.	1010
2120 Olds Cutlass Supreme	.	.	.	505	505	505	505	505	505	1505	1010
2220 Pontiac Grand Prix	.	.	.	505	505	505	505	505	505	1010	1010
1860 Cadillac Sedan C 113.8											
1903 Cadillac Sedan	.	.	.	.	.	1000	1000	1000	1000	.	.
									1010		
1861 Saturn coupe											
2402 Saturn SC coupe	.	.	.	.	.	.	404	404	404	1404	1010
								1404	1404		

Valid Occupant Protection Codes											
Car Group **Make/Model**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**
1862 Saturn sedan											
2401 Saturn SL sedan	.	.	.	.	.	.	404	404	404	1404	1010
								1404	1404		
2403 Saturn SW wagon	.	.	.	.	.	.	.	.	404	1404	1010
									1404		
1863 Cadillac Seville 111											
1914 Cadillac Seville	.	.	.	.	.	.	.	1000	1010	1010	1010
1864 Cadillac DeVille K											
1903 Cadillac DeVille	.	.	.	.	.	.	.	.	.	1010	1010
1865 GM Aurora/Riviera G 113.8											
1805 Buick Riviera	.	.	.	.	.	.	.	.	.	.	1010
2122 Oldsmobile Aurora	.	.	.	.	.	.	.	.	.	.	1010
1866 GM Cavalier/Sunfire J 104.1											
2016 Chevrolet Cavalier	.	.	.	.	.	.	.	.	.	.	1010
2216 Pontiac Sunfire	.	.	.	.	.	.	.	.	.	.	1010
3004 VW Front engine cars 94.5											
3038 VW Scirocco	0	0	0	0	.	.	.	.	.	.	.
3042 VW Cabriolet	0	0	0	0	0	1000	1000	1000	1000	.	.
3005 VW Quantum											
3041 VW Quantum	0	0	0	0	.	.	.	.	.	.	.
3006 VW Jetta 97.3											
3040 VW Jetta	0	0	0	0	0	606	606	606	606	606	1010
			707	707	707				1010	1010	
3042 VW Golf/GTI/Cabrio	0	0	0	0	0	606	606	606	606	606	404
			707	707	707					1010	1010
3045 VW Corrado	.	.	.	.	.	404	404	404	404	404	404
3007 VW Fox											
3044 VW Fox	.	.	0	0	0	0	606	606	606	.	.
						606					
3008 VW Passat											
3046 VW Passat	.	.	.	.	.	404	404	404	404	404	404
3204 Audi 4000											
3234 Audi 4000	0	0	0	.	.	.	.	.	.	.	.
3205 Audi 5000 105.8											
3235 Audi 5000	0	0	0	0	.	.	.	.	.	.	.
3237 Audi 100/200	.	.	.	.	0	1000	1000	1000	1010	1010	.
					1000			1010			
3240 Audi A6	.	.	.	.	.	.	.	.	.	.	1010
3242 Audi S6	.	.	.	.	.	.	.	.	.	.	1010
3206 Audi 80/90 100.2											
3236 Audi 80/90	.	.	.	0	0	1000	1000	1000	.	.	.
3207 Audi 90 102.8											
3236 Audi 90	.	.	.	.	.	.	.	.	1000?	1010	1010
									1010?		

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
3208 Audi Cabriolet											
3241 Audi Cabriolet	.	.	.	.	.	.	.	.	.	1010	1010
3406 BMW 500 103.8											
3435 BMW 500	0	0	0	0	.	.	.	.	.	.	.
3407 BMW 300 101											
3434 BMW 300	0	0	0	0	0	1000	1000	1000	1000	.	.
3408 BMW 600											
3436 BMW 600	0	0	0	1000	1000	.	.	.	.	.	.
3409 BMW 700 110											
3437 BMW 700	0	0	.	.	.	.	.	.	.	.	.
3410 BMW 700 111.5											
3437 BMW 700	.	.	0 1000	1000	1000	1000	1000	1000	1010	1010	.
3411 BMW 700L 116											
3437 BMW 700L	.	.	.	1000	1000	1000	1000	1000	1010	1010	.
3412 BMW 500 108.7											
3435 BMW 500	.	.	.	.	0 1000	1000	1000	1000	1000	1000 1010	1010
3413 BMW 850											
3438 BMW 850	.	.	.	.	.	.	1000	1000	1010	1010	1010
3414 BMW 300 106.3											
3434 BMW 300	.	.	.	.	.	.	.	1000	1000	1010	1010
3415 BMW 740i 115.4											
3437 BMW 740i	.	.	.	.	.	.	.	.	.	.	1010
3416 BMW 700iL 120.9											
3437 BMW 700iL	.	.	.	.	.	.	.	.	.	.	1010
3514 Nissan 280-300ZX 91.3											
3534 Nissan 300ZX	0	0	0	0	.	.	.	.	.	.	.
3515 Nissan 280-300ZX 2+2 99.2											
3534 Nissan 300ZX 2+2	0	0	0	0	.	.	.	.	.	.	.
3534 Nissan 300ZX	.	.	.	.	0	.	.	.	.	.	.
3518 Nissan Sentra 94.5											
3543 Nissan Sentra	0	0	.	.	.	.	.	.	.	.	.
3519 Nissan Stanza 97.2											
3542 Nissan Stanza	0	0	.	.	.	.	.	.	.	.	.
3520 Nissan Pulsar 95											
3544 Nissan Pulsar	0	0	.	.	.	.	.	.	.	.	.
3521 Nissan 200SX 95.5											
3532 Nissan 200SX	0	0	0	0	.	.	.	.	.	.	.

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
3522 Nissan Maxima/Stanza 100.4											
3539 Nissan Maxima	0	0	0 404	404	.	.	.	.	.	.	.
3542 Nissan Stanza sedan	.	.	0	0	0	.	.	.	.	.	.
3542 Nissan Stanza	.	.	.	.	.	404	404	404	.	.	.
5833 Infiniti G20	.	.	.	.	.	.	404	404	404 1010	1010	1010
3523 Nissan Stanza wagon 99											
3542 Nissan Stanza wagon	.	0	0	0	0	.	.	.	.	.	.
3524 Nissan Sentra/Pulsar 95.7											
3543 Nissan Sentra	.	.	0	0	0 404	404 505	404 505	404 505	404 505 1404 1505	404 505 1404 1505	1010
3544 Nissan Pulsar	.	.	0	0	0	404 1000	.	.	.	.	.
3546 Nissan NX	.	.	.	.	.	.	1000	1000	1505	.	.
3525 Nissan Maxima 104.3											
3539 Nissan Maxima	.	.	.	.	404	404	404	404 1404	404 1404	1404	.
3526 Nissan 240SX 97.4											
3532 Nissan 240SX	.	.	.	.	404 505	404	404	404	404	505	.
3527 Nissan 300ZX 96.5											
3534 Nissan 300ZX	.	.	.	.	.	505	505 1505	1505	1505	1010	1010
3528 Nissan 300ZX 2+2 101.2											
3534 Nissan 300ZX 2+2	.	.	.	.	.	505	505 1505	1505	1505	1010	1010
3529 Infiniti M30											
5831 Infiniti M30	.	.	.	.	.	1000	1000	1505	.	.	.
3530 Infiniti Q45											
5832 Infiniti Q45	.	.	.	.	.	1000	1000	1505	1505	1010	1010
3531 Nissan Axxess											
3548 Nissan Axxess	.	.	.	.	.	404	404	.	.	.	.
3532 Nissan Altima											
3547 Nissan Altima	.	.	.	.	.	.	.	.	1404	1010	1010
3533 Infiniti J30											
5834 Infiniti J30	.	.	.	.	.	.	.	.	1010	1010	1010
3534 Nissan Maxima 106.3											
3539 Nissan Maxima	.	.	.	.	.	.	.	.	.	.	1010
3535 Nissan 240SX 99.4											
3532 Nissan 240SX	.	.	.	.	.	.	.	.	.	.	1010

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
3707 Honda/Acura 96.5											
3731 Honda Civic sedan/SW	0	0	0	.	.	.	.	.	.	.	.
3732 Honda Accord	0	.	.	.	.	.	.	.	.	.	.
3733 Honda Prelude	0	0	0	.	.	.	.	.	.	.	.
5431 Acura Integra 3 door	.	0	0	0	0	.	.	.	.	.	.
3708 Honda CRX 86.6											
3735 Honda CRX	0	0	0	.	.	.	.	.	.	.	.
3709 Honda Civic 93.7											
3731 Honda Civic	0	0	0	.	.	.	.	.	.	.	.
3710 Honda Accord 102.4											
3732 Honda Accord	.	0	0 505	0 505	0 505	.	.	.	.	.	.
5431 Acura Integra sedan	.	.	.	.	.	404	404	404	404	.	.
3711 Acura Legend sedan 108.6											
5432 Acura Legend sedan	.	0	0 1000	0 1000	1000	1000	.	.	.	.	.
6131 Sterling	.	.	0 404	0 404	0 404	404	404	.	.	.	.
3712 Acura Integra 99.2											
5431 Acura Integra 5 door	.	0	0	0	0	.	.	.	.	.	.
3713 Acura Legend coupe 106.5											
5432 Acura Legend coupe	.	.	0	0	1000	1000	.	.	.	.	.
3714 Honda CRX 90.6											
3735 Honda CRX	.	.	.	0	0 505	505	505	1000	.	.	.
3715 Honda Civic 98.4											
3731 Honda Civic	.	.	.	0	0	404 505	404 505	.	.	.	.
3716 Honda Prelude 101											
3733 Honda Prelude	.	.	.	505	505	505	505	.	.	.	.
3717 Prelude/Integra 2HB 100.4											
3733 Honda Prelude	.	.	.	.	.	.	.	1000 1010	1000 1010	1010	1010
5431 Acura Integra 2HB	.	.	.	.	.	404	404	404	404	.	.
3718 Honda Accord 107.1											
3732 Honda Accord	.	.	.	.	.	404	404 1000	1000	1000 1010	.	.
3719 Acura NSX											
5433 Acura NSX	.	.	.	.	.	.	1000	1000	1010	1010	1010
3720 Acura Legend coupe 111.4											
5432 Acura Legend coupe	.	.	.	.	.	.	1000 1010	1000 1010	1010	1010	1010

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
3721 Acura Legend sedan 114.6											
5432 Acura Legend sedan	.	.	.	.	.	.	1000 1010	1000 1010	1010	1010	1010
3722 Honda Civic 2HB 101.3											
3731 Honda Civic 2HB	.	.	.	.	.	.	.	1000	1000	1010	1010
5431 Acura Integra 2HB	.	.	.	.	.	.	.	.	.	1010	1010
3723 Honda Civic sedan 103.2											
3731 Honda Civic sedan	.	.	.	.	.	.	.	1000	1000	1010	1010
5431 Acura Integra sedan	.	.	.	.	.	.	.	.	.	1010	1010
3724 Acura Vigor											
5434 Acura Vigor	.	.	.	.	.	.	.	1000	1000 1010	1010	.
3725 Honda Civic del Sol											
3735 Honda Civic del Sol	.	.	.	.	.	.	.	.	1000 1010	1010	1010
3726 Honda Accord 106.9											
3732 Honda Accord	.	.	.	.	.	.	.	.	.	1010	1010
3801 Isuzu I-Mark 94.3											
3831 Isuzu I-Mark	0	.	.	.	.	.	.	.	.	.	.
3802 Isuzu Impulse											
3832 Isuzu Impulse	0	0	0	303	303	.	.	.	.	.	.
3803 Chevrolet Spectrum											
2031 Chevrolet Spectrum	0	0	0	0	0	.	.	.	.	.	.
3831 Isuzu I-Mark	.	0	0	0	0	.	.	.	.	.	.
3804 Geo Storm											
2035 Geo Storm	.	.	.	.	.	1000	1000	1000	1000	.	.
3832 Isuzu Impulse	.	.	.	.	.	1000	1000	1000	.	.	.
3833 Isuzu Stylus	.	.	.	.	.	1000	1000	1000	1000	.	.
3903 Jaguar XJ Sedan 113											
3932 Jaguar XJ sedan	0	0	0	0	404	404	404	404	1000	1000 1010	1010
3904 Jaguar XJ-S coupe											
3931 Jaguar XJ-S	0	0	0	0 404	0 404	404 1000	1000	1000	1000	1010	1010
4107 Mazda RX-7 95.3											
4134 Mazda RX-7	0	.	.	.	.	.	.	.	.	.	.
4109 Mazda GLC 93.1											
4135 Mazda GLC	0	.	.	.	.	.	.	.	.	.	.
4110 Mazda 626 98.8 FWD											
4137 Mazda 626	0	0	0 404	.	.	.	.	.	.	.	.

Car Group Make/Model	Valid Occupant Protection Codes										
	85	86	87	88	89	90	91	92	93	94	95
4111 Mazda 323/Tracer											
1436 Mercury Tracer	.	.	.	0	0	303	.	.	.	.	.
4135 Mazda 323	.	0	0	0	0	.	.	.	.	.	.
4112 Mazda RX-7 95.7											
4134 Mazda RX-7	.	0	0	0	0	404	404	.	.	.	.
					404	1000	1000				
4113 Mazda 626 101.4											
4137 Mazda 626	.	.	.	0	404	404	404	404	.	.	.
				404							
4114 Mazda 929 106.7											
4143 Mazda 929	.	.	.	0	0	404	404	.	.	.	.
4115 Ford Probe 99											
1218 Ford Probe	.	.	.	.	0	303	303	303	.	.	.
4144 Mazda MX6	.	.	.	0	0	404	404	404	.	.	.
				404	404						
4116 Mazda 323 HB 96.5											
4135 Mazda 323	.	.	.	.	.	404	404	404	404	404	.
4117 Ford Escort 98.4											
1213 Ford Escort	.	.	.	.	.	303	303	303	303	1303	1313
1436 Mercury Tracer	.	.	.	.	.	.	303	303	303	1303	1313
4135 Mazda 323 Protege	.	.	.	.	.	404	404	404	404	404	.
4118 Mazda Miata											
4145 Mazda Miata	.	.	.	.	.	1000	1000	1000	1000	1010	1010
4119 Mazda MX3											
4146 Mazda MX3	.	.	.	.	.	.	.	404	404	1010	1010
4120 Mazda 929 112.2											
4143 Mazda 929	.	.	.	.	.	.	.	1010	1010	1010	1010
4121 Mazda 626/Probe 102.9											
1218 Ford Probe	.	.	.	.	.	.	.	.	1000	1010	1010
4137 Mazda 626	.	.	.	.	.	.	.	.	1000	1010	1010
4144 Mazda MX6	.	.	.	.	.	.	.	.	1000	1010	1010
4122 Mazda RX7 95.5											
4134 Mazda RX7	.	.	.	.	.	.	.	.	1000	1010	1010
4123 Mazda Protege 102.6											
4135 Mazda Protege	.	.	.	.	.	.	.	.	.	.	1010
4124 Mazda Millenia											
4147 Mazda Millenia	.	.	.	.	.	.	.	.	.	.	1010
4204 Mercedes SL roadster 96.9											
4233 Mercedes 380SL	0	.	.	.	.	.	.	.	.	.	.
4208 Mercedes basic sedan 110											
4231 Mercedes basic sedan	0	.	.	.	.	.	.	.	.	.	.

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
4209 Mercedes basic C coupe 106.7											
4231 Mercedes basic coupe	0	.	.	.	.	.	.	.	.	.	.
4210 Mercedes S (super) sedan 115.6											
4237 Mercedes SD/SE	0 1000	1000	1000	1000	1000 1010	1000 1010	1000 1010	.	.	.	.
4211 Mercedes SEL (long super) sedan 121.1											
4236 Mercedes SDL/SEL	0 1000	1000	1000	1000	1000 1010	1000 1010	1010	.	.	.	.
4212 Mercedes SEC coupe 112.2											
4236 Mercedes SEC	0 1000	1000	1000	1000	1000 1010	1000 1010	1010	.	.	.	.
4213 Mercedes 190											
4239 Mercedes 190	0 1000	1000	1000	1000	1000	1000 1010	1000 1010	1000 1010	1000 1010	.	.
4214 Mercedes basic E sedan 110.2											
4231 Mercedes basic sedan	.	1000	1000	1000	1000 1010	1000 1010	1000 1010	1000 1010	1010	.	.
4231 Mercedes E sedan	.	.	.	.	.	.	.	.	.	1010	1010
4215 Mercedes SL roadster 96.7											
4233 Mercedes 560SL	.	1000	1000	1000	1000	.	.	.	.	.	.
4216 Mercedes basic E coupe 106.9											
4231 Mercedes basic coupe	.	.	.	1000	1000 1010	1000 1010	1000 1010	1000 1010	1010	.	.
4231 Mercedes E coupe	.	.	.	.	.	.	.	.	.	1010	1010
4217 Mercedes SL roadster 99											
4233 Mercedes 300SL/500SL	.	.	.	.	.	1000 1010	1010	1010	1010	.	.
4233 Mercedes SL roadster	.	.	.	.	.	.	.	.	.	1010	1010
4218 Mercedes S sedan 119.7											
4236 Mercedes SEC coupe	.	.	.	.	.	.	.	1010	1010	.	.
4237 Mercedes SE/SD	.	.	.	.	.	.	.	1010	1010	.	.
4237 Mercedes S320/S350 sedan	.	.	.	.	.	.	.	.	.	1010	1010
4219 Mercedes long S sedan 123.6											
4236 Mercedes SEL sedan	.	.	.	.	.	.	.	1010	1010	.	.
4236 Mercedes S420/S500/S600 sedan	.	.	.	.	.	.	.	.	.	1010	1010
4220 Mercedes C sedan											
4242 Mercedes C sedan	.	.	.	.	.	.	.	.	.	1010	1010
4221 Mercedes S coupe 115.9											
4236 Mercedes S coupe	.	.	.	.	.	.	.	.	.	1010	1010
4406 Peugeot 505 sedan											
4434 Peugeot 505 sedan	0	0	0	0 606	0 606	404 606	404 606	.	.	.	.
4407 Peugeot 505 wagon											
4434 Peugeot 505 wagon	0	0	0	0 606	0 606	404 606	404 606	.	.	.	.

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
4408 Peugeot 405											
4436 Peugeot 405	.	.	.	.	0 404 606	404 606	404 606	.	.	.	.
4501 Porsche 911											
4531 Porsche 911	0	0	0	0	0	1010	1010	.	.	.	1010
4503 Porsche 924/944											
4534 Porsche 924	0	0	0	0	.	.	.	.	.	.	.
4537 Porsche 944	0	0	0 1010	0 1010	0 1010	1010	1010	.	.	.	.
4539 Porsche 968	.	.	.	.	.	.	.	.	.	.	1010
4504 Porsche 928											
4535 Porsche 928	0	0	0	0	0	1010	1010	.	.	.	1010
4505 Porsche											
4540 Porsche	.	.	.	.	.	.	.	1010	1010	1010	.
4605 Renault 18/Fuego											
4637 Renault R18i	0	0	.	.	.	.	.	.	.	.	.
4638 Renault Fuego	0	.	.	.	.	.	.	.	.	.	.
4606 Renault Alliance											
4639 Renault Alliance	0	0	0 505	.	.	.	.	.	.	.	.
4640 Renault Encore	0	0	.	.	.	.	.	.	.	.	.
4607 Renault Medallion sedan											
4644 Renault Medallion sedan	.	.	.	0	404	.	.	.	.	.	.
4608 Renault Medallion wagon											
4644 Renault Medallion wagon	.	.	.	0	404	.	.	.	.	.	.
4609 Eagle Premier											
740 Dodge Monaco	.	.	.	.	.	404	404	404	.	.	.
1040 Eagle Premier	.	.	.	0 404	0 404	404	404	404	.	.	.
4704 Saab 900 99.4											
4731 Saab 900	0	0	0 404	0 404	0 404	1000	1000	1000	1000	1000	.
4705 Saab 9000											
4734 Saab 9000	0	0	0	0 1000	0 1000	1000	1000	1000	1000	1010	1010
4706 Saab 900 102.4											
4731 Saab 900	.	.	.	.	.	.	.	.	.	1010	1010

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
4806 Subaru sedan 97											
4831 Subaru sedan	0	0	0	0 404	0 404	0 9 404	404	.	.	.	.
4831 Subaru Loyale	.	.	.	.	.	.	.	404	404	404	.
4835 Subaru XT	0	0	0 404	404	404	404	404	.	.	.	.
4807 Subaru hatchback 93											
4831 Subaru hatchback	0	0	0	0	0	.	.	.	.	.	.
4808 Subaru Justy											
4836 Subaru Justy	.	.	0	0	0	505	505	505	505	505	.
4809 Subaru Legacy 101.6											
4834 Subaru Legacy	.	.	.	.	.	404	404	404 1404	1404	1404	.
4810 Subaru SVX											
4837 Subaru SVX	.	.	.	.	.	.	.	1404	1404	1010	1010
4811 Subaru Impreza											
4838 Subaru Impreza	.	.	.	.	.	.	.	.	1000	1000 1010	1010
4812 Subaru Legacy 103.5											
4834 Subaru Legacy	.	.	.	.	.	.	.	.	.	.	1010
4911 Toyota Celica 98.4											
4933 Toyota Celica	0	0	.	.	.	.	.	.	.	.	.
4912 Toyota Cressida 104.1											
4935 Toyota Cressida	303	.	.	.	.	.	.	.	.	.	.
4916 Toyota Corolla 94.5											
4932 Toyota Corolla 2 door	0	0	0	.	.	.	.	.	.	.	.
4918 Toyota Supra 103											
4934 Toyota Supra	0	0	.	.	.	.	.	.	.	.	.
4919 Toyota Tercel/Corolla 95.7											
2032 Chevrolet Nova	0	0	0	0	.	.	.	.	.	.	.
2032 Geo Prizm	.	.	.	.	0 606	0 606	606	606	.	.	.
4932 Toyota Corolla 4 dr	0	0	0	0	0	606	606	606	.	.	.
4932 Toyota Corolla FX-16	.	.	0	0	0	.	.	.	.	.	.
4932 Toyota Corolla 2 dr	.	.	.	0	0	606	606	606	.	.	.
4938 Toyota Tercel	0	0	.	.	.	.	.	.	.	.	.
4938 Toyota Tercel wagon	0	0	0	.	.	.	.	.	.	.	.
4920 Toyota Camry 102.4											
4940 Toyota Camry	0	0	303	303	303	303	303	.	.	.	.
5731 Lexus ES-250	.	.	.	.	.	1000	1000	.	.	.	.
4921 Toyota MR-2 91.3											
4941 Toyota MR-2	0	0	0	0	0	.	.	.	.	.	.

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
4922 Toyota Cressida 104.5											
4935 Toyota Cressida	.	303	303	303	303	303	303	303	.	.	.
4923 Toyota Supra 102.2											
4934 Toyota Supra	.	0	0	0	0	1000	1000	1000	.	.	.
4924 Toyota Celica 99.4											
4933 Toyota Celica	.	.	0	0	0	1000	1000	1000	1000	.	.
4925 Toyota Tercel 93.7											
4938 Toyota Tercel	.	.	0	0	0	606	606	606	606	1006	1010
4942 Toyota Paseo	.	.	.	.	.	.	.	606	606	1006	1006
4926 Lexus LS-400 110.8											
5932 Lexus LS-400	.	.	.	.	.	1000	1000	1000	1010	1010	.
4927 Toyota MR-2 94.5											
4941 Toyota MR-2	.	.	.	.	.	.	1000	1000	1000	1010	1010
4928 Toyota Camry 103.1											
4940 Toyota Camry	.	.	.	.	.	.	.	1000	1000	1010	1010
5931 Lexus ES-300	.	.	.	.	.	.	.	1000	1000	1010	1010
4929 Lexus SC-300/400											
5933 Lexus SC-300/400	.	.	.	.	.	.	.	1000	1010	1010	1010
4930 Toyota Corolla 97											
2032 Geo Prizm	.	.	.	.	.	.	.	.	1000	1010	1010
4932 Toyota Corolla	.	.	.	.	.	.	.	.	1000	1010	1010
4931 Toyota Supra 100.4											
4934 Toyota Supra	.	.	.	.	.	.	.	.	1000	1010	1010
4932 Lexus GS-300											
5934 Lexus GS-300	.	.	.	.	.	.	.	.	1010	1010	1010
4933 Toyota Celica 99.9											
4933 Toyota Celica	.	.	.	.	.	.	.	.	.	1010	1010
4934 Lexus LS-400 112.2											
5932 Lexus LS-400	.	.	.	.	.	.	.	.	.	.	1010
4935 Toyota Avalon											
4943 Toyota Avalon	.	.	.	.	.	.	.	.	.	.	1010
5104 Volvo 240											
5134 Volvo 240	0	0	0	0	0	1000	1000	1000	1000	.	.
5105 Volvo 740/760											
5138 Volvo 760/780	0	0	0 1000	1000	1000	1000	1000	.	.	.	.
5139 Volvo 740	0	0	0 1000	0 1000	0 1000	1000	1000	1000	.	.	.
5140 Volvo 940	.	.	.	.	.	.	1000	1000	1000	1010	1010
5141 Volvo 960	.	.	.	.	.	.	1000	1000	1010	1010	1010
5106 Volvo 850											
5142 Volvo 850	.	.	.	.	.	.	.	.	1010	1010	1010

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
5204 Colt/Champ 90.6											
734 Dodge Colt 2 door	0	.	.	.	.	.	.	.	.	.	.
934 Plymouth Colt 2 door	0	.	.	.	.	.	.	.	.	.	.
5205 Hyundai Excel 93.7											
734 Dodge Colt 4 door	0	0	0	0	.	.	.	.	.	.	.
734 Dodge Colt 2 door	.	0	0	0	.	.	.	.	.	.	.
734 Dodge Colt DL wagon	.	.	.	.	0	404	.	.	.	.	.
934 Plymouth Colt 4 door	0	0	0	0	.	.	.	.	.	.	.
934 Plymouth Colt 2 door	.	0	0	0	.	.	.	.	.	.	.
934 Plymouth Colt DL wagon	.	.	.	.	0	404	.	.	.	.	.
5235 Mitsubishi Mirage	0	0	0	0	.	.	.	.	.	.	.
5236 Mitsubishi Precis	.	.	0	0	0	.	.	.	.	.	.
			707	707	707						
5532 Hyundai Excel	.	0	0	0	0	.	.	.	.	.	.
			707	707	707						
5206 Mitsubishi Starion											
635 Chrysler Conquest	.	.	404	404	404	.	.	.	.	.	.
735 Dodge Conquest	0	0	.	.	.	.	.	.	.	.	.
935 Plymouth Conquest	0	0	.	.	.	.	.	.	.	.	.
5231 Mitsubishi Starion	0	0	404	404	404	.	.	.	.	.	.
5207 Mitsubishi Tredia/Cordia											
5232 Mitsubishi Tredia	0	0	0	0	.	.	.	.	.	.	.
5233 Mitsubishi Cordia	0	0	0	0	.	.	.	.	.	.	.
5208 Colt Vista											
744 Dodge Colt Vista	0	0	0	0	0	404	404	.	.	.	.
944 Plymouth Colt Vista	0	0	0	0	0	404	404	.	.	.	.
5209 Mitsubishi Galant 102.4											
5234 Mitsubishi Galant	0	0	0	0	0	404	404	404	404	.	.
5238 Mitsubishi Sigma	.	.	.	.	0	1000	1000	.	.	.	.
5210 Mitsubishi Mirage 96.7											
1034 Eagle Summit sedan	.	.	.	.	404	404	404	404	.	.	.
5235 Mitsubishi Mirage sedan	.	.	.	.	404	404	404	404	.	.	.
5235 Mitsubishi Mirage hatchback	.	.	.	.	404	.	.	.	.	.	.
5211 Dodge Colt 93.9											
734 Dodge Colt 2HB	.	.	.	.	404	404	404	404	.	.	.
934 Plymouth Colt 2HB	.	.	.	.	404	404	404	404	.	.	.
5235 Mitsubishi Mirage 2HB	.	.	.	.	.	404	404	404	.	.	.
5212 Mitsubishi Eclipse 97.2											
937 Plymouth Laser	.	.	.	.	.	404	404	404	404	404	.
1037 Eagle Talon	.	.	.	.	.	404	404	404	404	404	.
5237 Mitsubishi Eclipse	.	.	.	.	.	404	404	404	404	404	.
5213 Dodge Stealth											
739 Dodge Stealth	.	.	.	.	.	.	1000	1000	1000	1010	1010
5239 Mitsubishi 3000GT	.	.	.	.	.	.	1000	1000	1000	1010	1010

Car Group Make/Model	Valid Occupant Protection Codes 85	86	87	88	89	90	91	92	93	94	95
5214 Mitsubishi LRV											
744 Dodge Colt Vista	.	.	.	.	.	.	.	404	404	1004	.
944 Plymouth Colt Vista	.	.	.	.	.	.	.	404	404	1004	.
1044 Eagle Summit wagon	.	.	.	.	.	.	.	404	404	1004	1010
5244 Mitsubishi LRV	.	.	.	.	.	.	.	404	404	1004	.
5215 Mitsubishi Diamante											
5240 Mitsubishi Diamante	.	.	.	.	.	.	.	1000	1000	1010	1010
5245 Mitsubishi Expo SP	.	.	.	.	.	.	.	404	404	1004	.
5216 Dodge Colt 2 door 96.1											
734 Dodge Colt 2 door	.	.	.	.	.	.	.	.	404	1004	.
934 Plymouth Colt 2 door	.	.	.	.	.	.	.	.	404	1004	.
1034 Eagle Summit 2 door	.	.	.	.	.	.	.	.	404	1004	1010
5235 Mitsubishi Mirage 2 door	.	.	.	.	.	.	.	.	404	1004	1010
5217 Dodge Colt 4 door 98.4											
734 Dodge Colt 4 door	.	.	.	.	.	.	.	.	404	1004	.
934 Plymouth Colt 4 door	.	.	.	.	.	.	.	.	404	1004	.
1034 Eagle Summit 4 door	.	.	.	.	.	.	.	.	404	1004	1010
5235 Mitsubishi Mirage 4 door	.	.	.	.	.	.	.	.	404	1004	1010
5218 Mitsubishi Galant 103.7											
643 Chrysler Sebring	.	.	.	.	.	.	.	.	.	.	1010
742 Dodge Avenger	.	.	.	.	.	.	.	.	.	.	1010
5234 Mitsubishi Galant	.	.	.	.	.	.	.	.	.	1010	1010
5219 Mitsubishi Eclipse 98.8											
1037 Eagle Talon	.	.	.	.	.	.	.	.	.	.	1010
5237 Mitsubishi Eclipse	.	.	.	.	.	.	.	.	.	.	1010
5301 Chevrolet Sprint 88.4											
2033 Chevrolet Sprint 4 door	0	0	.	.	.	.	.	.	.	.	.
2033 Chevrolet Sprint 2 door	0	0	0	0	.	.	.	.	.	.	.
5302 Chevrolet Sprint 92.3											
2033 Chevrolet Sprint 4 door	.	.	0	0	.	.	.	.	.	.	.
5303 Geo Metro 89.2											
2034 Geo Metro 2 door	.	.	.	.	0	505	505	505	505	505	.
						1000	1000	1000	1000		
5334 Suzuki Swift 2 door	.	.	.	.	0	505	505	505	505	505	.
5304 Geo Metro 93.1											
2034 Geo Metro 4 door	.	.	.	.	0	505	505	505	505	505	.
2034 Geo Metro	.	.	.	.	.	.	.	.	.	.	1010
5334 Suzuki Swift 4 door	.	.	.	.	0	505	505	505	505	505	.
5334 Suzuki Swift	.	.	.	.	.	.	.	.	.	.	1010
5501 Hyundai Sonata 104.3											
5533 Hyundai Sonata	.	.	.	.	0	404	404	404	404	404	.
					707					1010	
5502 Hyundai Excel 93.8											
5236 Mitsubishi Precis	.	.	.	.	.	606	606	606	606	606	.
5532 Hyundai Excel	.	.	.	.	.	606	606	606	606	606	.
5534 Hyundai Scoupe	.	.	.	.	.	.	606	606	606	606	606

Car Group Make/Model	Valid Occupant Protection Codes										
	85	86	87	88	89	90	91	92	93	94	95
5503 Hyundai Elantra											
5535 Hyundai Elantra	.	.	.	.	.	.	.	606	606	1006	1006
5504 Hyundai Accent											
5536 Hyundai Accent	.	.	.	.	.	.	.	.	.	.	1010
5505 Hyundai Sonata 106.3											
5533 Hyundai Sonata	.	.	.	.	.	.	.	.	.	.	1010
5603 Merkur XR4Ti											
5631 Merkur XR4Ti	0	0	0	0	0	.	.	.	.	.	.
5604 Merkur Scorpio											
5632 Merkur Scorpio	.	.	.	0	0	303	.	.	.	.	.
5701 Yugo											
5731 Yugo	.	0	0	0	0	606	606	.	.	.	.
				707	707						
6001 Daihatsu Charade											
6031 Daihatsu Charade	.	.	.	0	0	404	404	404	.	.	.
				606	606	606	606	606			
6301 Pontiac LeMans (Daewoo)											
2231 Pontiac LeMans	.	.	.	0	0	404	404	404	404	.	.
6401 Ford Festiva											
1234 Ford Festiva	.	.	.	0	0	303	303	303	303	.	.
6402 Kia Sephia											
6431 Kia Sephia	.	.	.	.	.	.	.	.	303	303	303
6403 Ford Aspire 2dr 90.7											
1236 Ford Aspire 2dr	.	.	.	.	.	.	.	.	.	1010	1010
6404 Ford Aspire 4dr 93.9											
1236 Ford Aspire 4dr	.	.	.	.	.	.	.	.	.	1010	1010
6501 Mercury Capri XR-2											
1431 Mercury Capri	.	.	.	.	0	303	1000	1000	1000	1010	.

APPENDIX B

LIGHT TRUCKS
TYPES OF OCCUPANT PROTECTION BY MAKE-MODEL AND YEAR

EXPLANATION OF CODES

.	trucks of this group or make-model were not sold in this model year
0	manual 3-point belts for driver and right-front (RF) passenger
9	occupant protection system unknown - or - 2 or more types offered that year, but VIN does not specify which type is on a particular vehicle
1000	driver air bag + manual 3-point belts for driver and RF
1010	dual air bags + manual 3-point belts for driver and RF

Note: If two types of occupant protection were offered in the same year, and the VIN can be used to identify which type is on a particular vehicle, the first type is shown on the first line, and the second type on the second line. Codes marked with a "?" are not used in the analyses. Pre-1991 light trucks are equipped with manual 3-point belts for driver and RF (code 0).

Light Truck Group Make/Model	Valid Occupant Protection Codes 91	92	93	94	95
7005 Jeep Cherokee	0	0	0	0	1000
7006 Jeep Wagoneer	0	0	.	.	.
7007 Jeep Grand Wagoneer	0	0	.	.	.
7010 Jeep Wrangler	0	0	0	0	0
7011 Jeep Comanche 113/119.9	0	0	.	.	.
7102 Dodge D/W 150 Pickup	0	0	0	1000?	.
7103 Dodge D/W 250/350 Pickup	0	0	0	1000?	.
7105 Dodge Ramcharger	0	0	0	0	.
7106 Dodge Ram Van 109.6/127.6	0	0	0	0	1000
7107 Dodge Ram Van 127.6	0	0	0	0	1000
7108 Dodge Dakota 111.9/123.9	0	0	0	1000	1000
7110 Dodge D/W Club Cab Pickup 149	0	0	0	1000	.
7111 Dodge Dakota Club Cab 131	0	0	0	1000	1000
7112 Caravan/Voyager 112.3	9	1000	1000	1010	1010
7113 Grand Caravan/Voyager/Town-Country 119.3	9	1000	1000	1010	1010
7114 Jeep Grand Cherokee					
7017 Jeep Grand Cherokee	.	.	1000	1000	1000
7018 Jeep Grand Cherokee 4x4	.	.	1000	1000	1000
7019 Jeep Grand Wagoneer 4x4	.	.	1000	.	.
7115 Dodge Ram 1500 Pickup	.	.	.	1000	1000
7116 Dodge Ram 2500/3500 Pickup	.	.	.	1000	1000
7117 Dodge Ram Club Cab Pickup	.	.	.	1000	1000
7401 Ford Ranger 107.9/113.9	0	0	.	.	.
7402 Ford F150 Pickup	0	0	0	1000	1000
7403 Ford F250/350 Pickup	0	0	0	1000	1000
7404 Ford F150 Supercab Pickup	0	0	0	0	1000
7405 Ford F250/350 Supercab Pickup	0	0	0	0	1000
7407 Ford Bronco	0	0	0	1000	1000
7409 Ford van 138	0	.	.	.	.
7410 Ford Ranger Supercab	0	0	.	.	.
7411 Ford Aerostar	0	1000	1000	1000	1000

Light Truck Group Make/Model	Valid Occupant Protection Codes 91	92	93	94	95
7412 Ford F350 Crew Cab Pickup 168.4	0	0	0	0	0
7413 Ford Explorer 2dr 102.1					
7440 Ford Explorer 2dr	0	0	0	0	9
7441 Ford Explorer 2dr 4x4	0	0	0	0	9
8310 Mazda Navajo 4x4	0	0	0	0	.
8311 Mazda Navajo	0	0	0	0	.
7414 Ford Explorer 4dr 111.9	0	0	0	0	9
7415 Ford van 138 (92 redesign)	.	0	0 1000	0 1000	1000
7416 Ford Ranger 108.0/114.0					
7452 Ford Ranger	.	.	0	0	1000
7453 Ford Ranger 4x4	.	.	0	0	1000
8310 Mazda B pickup	.	.	.	0	9
8311 Mazda B pickup 4x4	.	.	.	0	9
7417 Ford Ranger Supercab (1993 redesign)					
7454 Ford Ranger Supercab	.	.	0	0	1000
7455 Ford Ranger Supercab 4x4	.	.	0	0	1000
8312 Mazda B cab-plus pickup	.	.	.	0	9
8313 Mazda B cab-plus pickup 4x4	.	.	.	0	9
7418 Mercury Villager/Nissan Quest	.	.	9	9	9
7419 Ford Windstar	.	.	.	.	1010
7604 GM S Blazer/Jimmy 2dr 100.5	0	0	0	0	0
7605 GM K/V Blazer/Jimmy 106.5	0	.	.	.	.
7606 GM C/K/R/V 10 Suburban 129.5	0	.	.	.	.
7607 GM C/K/R/V 20 Suburban 129.5	0	.	.	.	.
7608 GM Astro/Safari van	0	0	0	1000	1000
7609 GM full-sized van 110/125	0	0	0	1000	1000
7610 GM full-sized van 125					
7621 Chevrolet G20 Sportvan	0	0	0	1000	1000
7622 Chevrolet G30 Chevy Van	0	0	0	0 1000	0 1000
7623 Chevrolet G30 Sportvan	0	0	0	0 1000	0 1000
7721 GMC 2500 Rally	0	0	0	1000	1000
7722 GMC 3500 Vandura	0	0	0	0 1000	0 1000
7723 GMC 3500 Rally	0	0	0	0 1000	0 1000
7612 GM C/K/R/V 20/30 4 dr pickup 164.5	0	.	.	.	.
7613 GM S/T pickup 108.3/117.9	0	0	0	0	1000
7614 GM S/T Maxicab pickup	0	0	0	0	1000

Light Truck Group Make/Model	Valid Occupant Protection Codes 91	92	93	94	95
7615 GM C/K 1500 pickup 117.5/131.5	0	0	0	0	1000
7616 GM C/K 2500/3500 pickup 131.5	0	0	0	0	1000
7617 GM C/K extended-cab pickup 155.5	0	0	0	0	1000
7618 GM extended van 146	0	0	0	0 1000	0 1000
7619 GM Lumina APV/Silhouette/Trans Sport	0	0	0	1000	1000
7620 GM C/K extended-cab pickup 141.5/155.5	0	0	0	0	1000
7621 GM S Blazer/Jimmy 4dr 107.0					
7657 Chevrolet S10 Blazer 4dr	0	0	0	0	1000
7658 Chevrolet S10 4x4 Blazer 4dr	0	0	0	0	1000
7757 GMC S15 Jimmy 4dr	0	0	0	0	1000
7758 GMC S15 4x4 Jimmy 4dr	0	0	0	0	1000
7802 Oldsmobile Bravada 4x4	0	0	0	0	1000?
7622 GM C/K3500 Crew Cab pickup 168.5	.	0	0	0	0
7623 GM Tahoe/Yukon 111.5					
7662 Chevrolet K1500 4x4 Blazer	.	0	0	0	.
7662 Chevrolet 4x4 Tahoe	.	.	.	.	1000?
7762 GMC 4x4 Yukon	.	0	0	0	0?
7624 GM C/K 1500 Suburban 131.5	.	0	0	0	1000
7625 GM C/K 2500 Suburban 131.5	.	0	0	0	1000
8001 VW Vanagon	0	.	.	.	.
8103 Nissan pickup 104.3	0	0	0	0	0
8104 Nissan pickup 116.1	0	0	0	0	0
8105 Nissan Pathfinder	0	0	0	0	0
8203 Isuzu Trooper II 104.3	0	.	.	.	.
8204 Isuzu PUP 105.6	0	0	0	0	0
8205 Isuzu PUP 119.2	0	0	0	0	0
8206 Isuzu Amigo	0	0	0	0	0
8208 Isuzu Rodeo	0	0	0	0	0
8209 Isuzu Trooper 4dr 108.7	.	0	0	0	1010
8102 Isuzu Trooper 2dr 91.7	.	.	0	0	1010
8211 Honda Passport	.	.	.	0	0
8301 Mazda pickup 108.7	0	0	0	.	.
8302 Mazda pickup 117.5	0	0	0	.	.

Light Truck Group Make/Model	Valid Occupant Protection Codes 91	92	93	94	95
8303 Mazda MPV	0	0	1000	1000	1000
8501 Toyota pickup 103	0	0	0	0	0
8502 Toyota pickup 112.2	0	0	0	0	0
8503 Toyota 4Runner	0	0	0	0	0
8506 Toyota pickup 121.5	0	0	0	0	0
8507 Toyota Land Cruiser 112.2	0	0	0	0	0
8508 Toyota Previa	0	1000	1000	1010	1010
8509 Toyota T100 pickup	.	.	0	1000	1000
8602 Mitsubishi Montero 2dr 92.5	0	.	.	.	.
8603 Mitsubishi Mighty Max pickup 105	0	0	0	0	0
8604 Mitsubishi Mighty Max pickup 116	0	0	0	0	.
8606 Mitsubishi Montero 4dr 106.1	0	.	.	.	.
8607 Mitsubishi Montero 4dr 107.3	.	0	0	1000	1000
8701 Suzuki Samurai	0	0	0	0	0
8702 Suzuki Sidekick/Tracker 2dr 86.6	0	0	0	0	0
8703 Suzuki Sidekick 4dr 97.6	0	0	0	0	0
8801 Daihatsu Rocky	0	0	.	.	.
9001 Kia Sportage	.	.	.	.	0

APPENDIX C

SUPPLEMENTARY TABLES
DETAILED ANALYSES OF FATALITY REDUCTION

TABLE C-1 - **CARS UP TO 2778 POUNDS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

(both seats occupied; make-models that had manual or automatic
3-point belts and added driver air bags without changing the belt system)

	Driver Fatalities	**Right Front Fatalities**	**Risk Ratio**	**Percent Reduction**
		IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)		
Cars with belts only	268	291	.921	
Cars w. driver air bags	114	171	.667	28
		(statistically significant difference: $\chi^2 = 4.81$)		
		IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)		
Cars with belts only	239	269	.888	
Cars w. driver air bags	126	133	.947	- 7
		(not a statistically significant difference: $\chi^2 = 0.18$)		
		IN ALL CRASHES		
Cars with belts only	848	923	.919	
Cars w. driver air bags	457	536	.853	7
		(not a statistically significant difference: $\chi^2 = 0.88$)		

TABLE C-2 - **CARS 2779-3119 POUNDS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

(both seats occupied; make-models that had manual or automatic
3-point belts and added driver air bags without changing the belt system)

	Driver Fatalities	**Right Front Fatalities**	**Risk Ratio**	**Percent Reduction**
IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Cars with belts only	236	259	.911	
Cars w. driver air bags	112	177	.633	31
(statistically significant difference: $\chi^2 = 5.89$)				
IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Cars with belts only	233	229	1.017	
Cars w. driver air bags	144	147	.980	4
(not a statistically significant difference: $\chi^2 = 0.06$)				
IN ALL CRASHES				
Cars with belts only	778	847	.919	
Cars w. driver air bags	452	540	.837	9
(not a statistically significant difference: $\chi^2 = 1.32$)				

TABLE C-3 - **CARS OVER 3119 POUNDS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

(both seats occupied; make-models that had manual or automatic
3-point belts and added driver air bags without changing the belt system)

	Driver Fatalities	**Right Front Fatalities**	**Risk Ratio**	**Percent Reduction**
	IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Cars with belts only	321	317	1.013	
Cars w. driver air bags	87	150	.580	43
	(statistically significant difference: $\chi^2 = 12.85$)			
	IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Cars with belts only	226	244	.926	
Cars w. driver air bags	120	128	.938	- 1
	(not a statistically significant difference: $\chi^2 = 0.01$)			
	IN ALL CRASHES			
Cars with belts only	890	945	.942	
Cars w. driver air bags	404	491	.823	13
	(not a statistically significant difference: $\chi^2 = 2.73$)			

TABLE C-4 - **CARS UP TO 2778 POUNDS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts
and added driver air bags without changing the belt system;
excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	847	539	
Purely frontal fatalities	907	396	31
(statistically significant difference: $\chi^2 = 21.38$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	847	539	
Partially frontal fatalities	650	363	12
(not a statistically significant difference: $\chi^2 = 2.33$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	847	539	
Frontal fatalities	1557	759	23
(statistically significant difference: $\chi^2 = 14.25$)			

Fatality reduction for driver air bags in all types of crashes: 15 percent

TABLE C-5- **CARS 2779-3119 POUNDS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts
and added driver air bags without changing the belt system;
excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	617	381	
Purely frontal fatalities	603	311	16
(not a statistically significant difference: $\chi^2 = 3.55$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	617	381	
Partially frontal fatalities	549	317	6
(not a statistically significant difference: $\chi^2 = 0.49$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	617	381	
Frontal fatalities	1152	628	12
(not a statistically significant difference: $\chi^2 = 2.32$)			

Fatality reduction for driver air bags in all types of crashes: 8 percent

TABLE C-6 - **CARS OVER 3119 POUNDS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts
and added driver air bags without changing the belt system;
excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	Cars with Driver Air Bags	Frontal Fat. Red. for Air Bags (%)
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	377	201	
Purely frontal fatalities	395	140	34
(statistically significant difference: $\chi^2 = 9.69$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	377	201	
Partially frontal fatalities	318	164	3
(not a statistically significant difference: $\chi^2 = 0.06$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	377	201	
Frontal fatalities	713	304	20
(not a statistically significant difference: $\chi^2 = 2.41$)			

Fatality reduction for driver air bags in all types of crashes: 13 percent

TABLE C-7 - **SINGLE-VEHICLE CRASHES**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

(both seats occupied; make-models that had manual or automatic 3-point belts and added driver air bags without changing the belt system)

	Driver Fatalities	Right Front Fatalities	Risk Ratio	Percent Reduction
IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Cars with belts only	266	280	.950	
Cars w. driver air bags	117	158	.741	22
(not a statistically significant difference: $\chi^2 = 2.80$)				
IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Cars with belts only	363	395	.918	
Cars w. driver air bags	216	221	.977	- 6
(not a statistically significant difference: $\chi^2 = 0.26$)				
IN ALL CRASHES				
Cars with belts only	1080	1115	.968	
Cars w. driver air bags	602	648	.929	4
(not a statistically significant difference: $\chi^2 = 0.35$)				

TABLE C-8 - **MULTIVEHICLE CRASHES**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

(both seats occupied; make-models that had manual or automatic
3-point belts and added driver air bags without changing the belt system)

	Driver Fatalities	Right Front Fatalities	Risk Ratio	Percent Reduction
IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Cars with belts only	559	587	.952	
Cars w. driver air bags	196	340	.576	39
(statistically significant difference: $\chi^2 = 22.01$)				
IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Cars with belts only	335	347	.965	
Cars w. driver air bags	174	187	.930	4
(not a statistically significant difference: $\chi^2 = 0.08$)				
IN ALL CRASHES				
Cars with belts only	1436	1600	.898	
Cars w. driver air bags	711	919	.774	14
(statistically significant difference: $\chi^2 = 5.78$)				

TABLE C-9 - **SINGLE-VEHICLE CRASHES**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts
and added driver air bags without changing the belt system;
excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
	PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)		
Nonfrontal fatalities	926	607	
Purely frontal fatalities	736	358	26
	(statistically significant difference: $\chi^2 = 12.97$)		
	PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)		
Nonfrontal fatalities	926	607	
Partially frontal fatalities	885	511	12
	(not a statistically significant difference: $\chi^2 = 2.77$)		
	ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)		
Nonfrontal fatalities	926	607	
Frontal fatalities	1621	869	18
	(statistically significant difference: $\chi^2 = 9.01$)		

Fatality reduction for driver air bags in all single-vehicle crashes: 12 percent

TABLE C-10- **MULTIVEHICLE CRASHES**, BY IMPACT LOCATION: EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts
and added driver air bags without changing the belt system;
excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	915	514	
Purely frontal fatalities	1169	489	26
(statistically significant difference: $\chi^2 = 14.67$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	915	514	
Partially frontal fatalities	632	333	6
(not a statistically significant difference: $\chi^2 = 0.54$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	915	514	
Frontal fatalities	1801	822	19
(statistically significant difference: $\chi^2 = 8.98$)			

Fatality reduction for driver air bags in all multivehicle crashes: 12 percent

TABLE C-11 - **DRIVERS AGE 14-29**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

(both seats occupied by people age 14-29; make-models that had manual or automatic 3-point belts and added driver air bags without changing the belt system)

	Driver Fatalities	Right Front Fatalities	Risk Ratio	Percent Reduction
IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Cars with belts only	267	247	1.081	
Cars w. driver air bags	98	145	.676	37
(statistically significant difference: $\chi^2 = 8.92$)				
IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Cars with belts only	284	298	.953	
Cars w. driver air bags	152	165	.921	3
(not a statistically significant difference: $\chi^2 = 0.36$)				
IN ALL CRASHES				
Cars with belts only	930	935	.995	
Cars w. driver air bags	473	550	.860	14
(statistically significant difference: $\chi^2 = 5.91$)				

TABLE C-12 - **DRIVERS AGE 56 OR OLDER**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

(**both seats occupied by people age 56+**; make-models that had manual or automatic 3-point belts and added driver air bags without changing the belt system)

	Driver Fatalities	Right Front Fatalities	Risk Ratio	Percent Reduction
IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Cars with belts only	234	300	.780	
Cars w. driver air bags	95	177	.537	31
(statistically significant difference: $\chi^2 = 5.90$)				
IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Cars with belts only	150	191	.785	
Cars w. driver air bags	108	124	.871	- 11
(not a statistically significant difference: $\chi^2 = 0.37$)				
IN ALL CRASHES				
Cars with belts only	658	857	.768	
Cars w. driver air bags	360	519	.694	10
(not a statistically significant difference: $\chi^2 = 1.40$)				

TABLE C-13 - **DRIVERS AGE 14-29**, BY IMPACT LOCATION: EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts
and added driver air bags without changing the belt system;
excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	840	505	
Purely frontal fatalities	745	328	27
(statistically significant difference: $\chi^2 = 12.87$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	840	505	
Partially frontal fatalities	692	360	13
(not a statistically significant difference: $\chi^2 = 2.83$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	840	505	
Frontal fatalities	1437	688	20
(statistically significant difference: $\chi^2 = 9.76$)			

Fatality reduction for driver air bags in all types of crashes: 13 percent

TABLE C-14 - **DRIVERS AGE 30-55**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts and added driver air bags without changing the belt system; excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	579	364	
Purely frontal fatalities	653	267	35
(statistically significant difference: $\chi^2 = 29.08$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	579	364	
Partially frontal fatalities	519	283	13
(not a statistically significant difference: $\chi^2 = 2.04$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	579	364	
Frontal fatalities	1172	550	25
(statistically significant difference: $\chi^2 = 12.00$)			

Fatality reduction for driver air bags in all types of crashes: 17 percent

TABLE C-15 - **DRIVERS AGE 56 OR OLDER**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts
and added driver air bags without changing the belt system;
excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	422	252	
Purely frontal fatalities	507	252	17
(not a statistically significant difference: $\chi^2 = 2.75$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	422	252	
Partially frontal fatalities	306	201	- 10
(not a statistically significant difference: $\chi^2 = 0.62$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	422	252	
Frontal fatalities	813	453	7
(not a statistically significant difference: $\chi^2 = 0.49$)			

Fatality reduction for driver air bags in all types of crashes: 4 percent

TABLE C-16 - **DRIVERS AGE 56-69**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts and added driver air bags without changing the belt system; excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	Cars with Driver Air Bags	Frontal Fat. Red. for Air Bags (%)
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	172	103	
Purely frontal fatalities	237	109	23
(not a statistically significant difference: $\chi^2 = 2.41$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	172	103	
Partially frontal fatalities	131	85	- 8
(not a statistically significant difference: $\chi^2 = 0.18$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	172	103	
Frontal fatalities	368	194	12
(not a statistically significant difference: $\chi^2 = 0.70$)			

Fatality reduction for driver air bags in all types of crashes: 8 percent

TABLE C-17 - **DRIVERS AGE 70 OR OLDER**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts
and added driver air bags without changing the belt system;
excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	250	149	
Purely frontal fatalities	270	143	11
(not a statistically significant difference: $\chi^2 = 0.65$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	250	149	
Partially frontal fatalities	175	116	- 11
(not a statistically significant difference: $\chi^2 = 0.45$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	250	149	
Frontal fatalities	445	259	2
(not a statistically significant difference: $\chi^2 = 0.03$)			

Fatality reduction for driver air bags in all types of crashes: 2 percent

TABLE C-18 - CAR DRIVERS, **INCLUDING ALL MAKE-MODELS**: EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(all 1985-95 cars that had manual or automatic 3-point belts only,
or had driver air bags plus 3-point belts;
including make-models that got ABS at the same time as air bags)

	Cars with Belts Only	**Cars with Driver Air Bags**	**OBSERVED Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	18,098	2180	
Purely frontal fatalities	20,061	1611	33
BIAS over analysis with matching make-models and control for ABS: 6 percent			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	18,098	2180	
Partially frontal fatalities	14,940	1612	10
BIAS over analysis with matching make-models and control for ABS: 1 percent			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	18,098	2180	
Frontal fatalities	35,001	3223	24
BIAS over analysis with matching make-models and control for ABS: 5 percent			

Observed fatality reduction for driver air bags in all types of crashes: 16 percent
BIAS over analysis with matching make-models and control for ABS: 4 percent

TABLE C-19 - **DRIVERS AGE 56-69, INCLUDING ALL MAKE-MODELS**:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(all 1985-95 cars that had manual or automatic 3-point belts only,
or had driver air bags plus 3-point belts;
including make-models that got ABS at the same time as air bags)

	Cars with Belts Only	Cars with Driver Air Bags	Frontal Fat. Red. for Air Bags (%) Observed	Adjusted
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Nonfrontal fatalities	1996	263		
Purely frontal fatalities	2745	244	33	27
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Nonfrontal fatalities	1996	263		
Partially frontal fatalities	1665	203	7	6
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)				
Nonfrontal fatalities	1996	263		
Frontal fatalities	4410	447	23	18
Fatality reduction for driver air bags in all types of crashes:			**16**	**12**

TABLE C-20 - **DRIVERS AGE 70 OR OLDER, INCLUDING ALL MAKE-MODELS**: EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(all 1985-95 cars that had manual or automatic 3-point belts only, or had driver air bags plus 3-point belts; including make-models that got ABS at the same time as air bags)

	Cars with Belts Only	Cars with Driver Air Bags	Frontal Fat. Red. for Air Bags (%) Observed	Frontal Fat. Red. for Air Bags (%) Adjusted
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Nonfrontal fatalities	2996	394		
Purely frontal fatalities	3038	331	17	11
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Nonfrontal fatalities	2996	394		
Partially frontal fatalities	2046	280	- 4	- 5
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)				
Nonfrontal fatalities	2996	394		
Frontal fatalities	5084	611	9	4
Fatality reduction for driver air bags in all types of crashes:			**5**	**1**

TABLE C-21 - **MALE DRIVERS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts and added driver air bags without changing the belt system; excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	1180	727	
Purely frontal fatalities	1283	569	28
(statistically significant difference: $\chi^2 = 22.77$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	1180	727	
Partially frontal fatalities	1031	560	12
(not a statistically significant difference: $\chi^2 = 3.19$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	1180	727	
Frontal fatalities	2314	1129	21
(statistically significant difference: $\chi^2 = 15.40$)			

Fatality reduction for driver air bags in all types of crashes: 14 percent

TABLE C-22 - **FEMALE DRIVERS**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(make-models that had manual or automatic 3-point belts and added driver air bags without changing the belt system; excluding make-models that got ABS at the same time as air bags)

	Cars with Belts Only	Cars with Driver Air Bags	Frontal Fat. Red. for Air Bags (%)
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	661	394	
Purely frontal fatalities	622	278	25
(statistically significant difference: $\chi^2 = 8.98$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	661	394	
Partially frontal fatalities	486	284	2
(not a statistically significant difference: $\chi^2 = 0.04$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	661	394	
Frontal fatalities	1108	562	15
(statistically significant difference: $\chi^2 = 3.87$)			

Fatality reduction for driver air bags in all types of crashes: 9 percent

TABLE C-23 - **MALE DRIVERS, INCLUDING ALL MAKE-MODELS**: EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(all 1985-95 cars that had manual or automatic 3-point belts only,
or had driver air bags plus 3-point belts;
including make-models that got ABS at the same time as air bags)

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**	
			Observed	**Adjusted**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Nonfrontal fatalities	10,668	1395		
Purely frontal fatalities	12,662	1090	34	28
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Nonfrontal fatalities	10,668	1395		
Partially frontal fatalities	9,528	1074	14	13
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)				
Nonfrontal fatalities	10,668	1395		
Frontal fatalities	22,190	2164	25	20
Fatality reduction for driver air bags in all types of crashes:			**17**	**13**

TABLE C-24- **FEMALE DRIVERS, INCLUDING ALL MAKE-MODELS**:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

(all 1985-95 cars that had manual or automatic 3-point belts only,
or had driver air bags plus 3-point belts;
including make-models that got ABS at the same time as air bags)

	Cars with Belts Only	Cars with Driver Air Bags	Frontal Fat. Red. for Air Bags (%) Observed	Adjusted
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Nonfrontal fatalities	7,429	785		
Purely frontal fatalities	7,399	521	33	27
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Nonfrontal fatalities	7,429	785		
Partially frontal fatalities	5,411	538	6	5
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)				
Nonfrontal fatalities	7,429	785		
Frontal fatalities	12,810	1059	22	17
Fatality reduction for driver air bags in all types of crashes:			**14**	**10**

TABLE C-25 - CAR DRIVERS, **INCLUDING ALL MAKE-MODELS**:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
DRIVER FATALITIES RELATIVE TO RIGHT FRONT PASSENGER FATALITIES

EXTENDED DATA SET: ALL 1985-95 CARS WITH DRIVER AIR BAGS AND 3-POINT BELTS
VS. ALL 1985-95 CARS WITH 3-POINT BELTS ONLY

	Driver Fatalities	**Right Front Fatalities**	**Risk Ratio**	**Percent Reduction**
IN PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Cars with belts only	5,422	5,880	.922	
Cars w. driver air bags	444	682	.651	29
(statistically significant difference: $\chi^2 = 29.98$)				
IN PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Cars with belts only	4,576	4,591	.997	
Cars w. driver air bags	535	559	.957	4
(not a statistically significant difference: $\chi^2 = 0.40$)				
IN ALL CRASHES				
Cars with belts only	16,423	17,622	.932	
Cars w. driver air bags	1,813	2,168	.836	10
(statistically significant difference: $\chi^2 = 10.39$)				

TABLE C-26 - **DRIVERS WITH UNKNOWN BELT USE**, BY IMPACT LOCATION:
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS
WITH UNKNOWN BELT USE ACCORDING TO FARS

LIMITED DATA SET: MAKE-MODELS THAT HAD MANUAL OR AUTOMATIC 3-POINT BELTS
AND ADDED DRIVER AIR BAGS WITHOUT CHANGING THE BELT SYSTEM,
EXCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	192	102	
Purely frontal fatalities	166	99	- 9
(not a statistically significant difference: $\chi^2 = 0.23$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	192	102	
Partially frontal fatalities	135	85	- 19
(not a statistically significant difference: $\chi^2 = 0.85$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	192	102	
Frontal fatalities	301	181	- 13
(not a statistically significant difference: $\chi^2 = 0.64$)			

Fatality reduction for driver air bags in all types of crashes: negative 8 percent

TABLE C-27 - **DRIVERS WITH UNKNOWN BELT USE**, BY IMPACT LOCATION: EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS WITH UNKNOWN BELT USE ACCORDING TO FARS

EXTENDED DATA SET: ALL 1985-95 CARS WITH DRIVER AIR BAGS AND 3-POINT BELTS VS. ALL 1985-95 CARS WITH 3-POINT BELTS ONLY, INCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

			Frontal Fat. Red. for Air Bags (%)	
	Cars with Belts Only	**Cars with Driver Air Bags**	**Observed**	**Adjusted**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Nonfrontal fatalities	1921	201		
Purely frontal fatalities	1996	194	7	1
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Nonfrontal fatalities	1921	201		
Partially frontal fatalities	1491	164	- 5	- 6
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)				
Nonfrontal fatalities	1921	201		
Frontal fatalities	3487	358	2	- 3
Fatality reduction for driver air bags in all types of crashes:			**1**	**- 3**

TABLE C-28 - **DRIVERS WITH OVER 68 PERCENT EXPECTED BELT USE**
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS WITH OVER 68 PERCENT EXPECTED BELT USE, BASED ON THEIR STATE, ALCOHOL STATUS, VEHICLE AGE AND THE CALENDAR YEAR

LIMITED DATA SET: MAKE-MODELS THAT HAD MANUAL OR AUTOMATIC 3-POINT BELTS AND ADDED DRIVER AIR BAGS WITHOUT CHANGING THE BELT SYSTEM, EXCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	233	245	
Purely frontal fatalities	266	193	31
(statistically significant difference: $\chi^2 = 7.97$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	233	245	
Partially frontal fatalities	156	198	-21
(not a statistically significant difference: $\chi^2 = 1.79$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	233	245	
Frontal fatalities	422	391	12
(not a statistically significant difference: $\chi^2 = 1.20$)			

Fatality reduction for driver air bags in all types of crashes: 8 percent

TABLE C-29 - **DRIVERS WITH OVER 68 PERCENT EXPECTED BELT USE**
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS WITH OVER 68 PERCENT EXPECTED BELT USE, BASED ON THEIR STATE, ALCOHOL STATUS, VEHICLE AGE AND THE CALENDAR YEAR

EXTENDED DATA SET: ALL 1985-95 CARS WITH DRIVER AIR BAGS AND 3-POINT BELTS VS. ALL 1985-95 CARS WITH 3-POINT BELTS ONLY, INCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

			Frontal Fat. Red. for Air Bags (%)	
	Cars with Belts Only	**Cars with Driver Air Bags**	**Observed**	**Adjusted**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Nonfrontal fatalities	1676	527		
Purely frontal fatalities	1824	427	26	20
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Nonfrontal fatalities	1676	527		
Partially frontal fatalities	1168	396	- 8	- 9
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)				
Nonfrontal fatalities	1676	527		
Frontal fatalities	2992	823	13	8
Fatality reduction for driver air bags in all types of crashes:			**8**	**4**

TABLE C-30 - **DRIVERS WITH 57-68 PERCENT EXPECTED BELT USE**
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS WITH 57-68 PERCENT EXPECTED BELT USE, BASED ON THEIR STATE, ALCOHOL STATUS, VEHICLE AGE AND THE CALENDAR YEAR

LIMITED DATA SET: MAKE-MODELS THAT HAD MANUAL OR AUTOMATIC 3-POINT BELTS AND ADDED DRIVER AIR BAGS WITHOUT CHANGING THE BELT SYSTEM, EXCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	467	373	
Purely frontal fatalities	425	283	17
(not a statistically significant difference: $\chi^2 = 3.09$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	467	373	
Partially frontal fatalities	330	270	-2
(not a statistically significant difference: $\chi^2 = 0.05$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	467	373	
Frontal fatalities	755	553	8
(not a statistically significant difference: $\chi^2 = 0.94$)			

Fatality reduction for driver air bags in all types of crashes: 5 percent

TABLE C-31 - **DRIVERS WITH 57-68 PERCENT EXPECTED BELT USE**
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS WITH 57-68 PERCENT EXPECTED BELT USE, BASED ON THEIR STATE, ALCOHOL STATUS, VEHICLE AGE AND THE CALENDAR YEAR

EXTENDED DATA SET: ALL 1985-95 CARS WITH DRIVER AIR BAGS AND 3-POINT BELTS VS. ALL 1985-95 CARS WITH 3-POINT BELTS ONLY, INCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

			Frontal Fat. Red. for Air Bags (%)	
	Cars with Belts Only	**Cars with Driver Air Bags**	**Observed**	**Adjusted**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Nonfrontal fatalities	3479	762		
Purely frontal fatalities	3399	543	27	21
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Nonfrontal fatalities	3479	762		
Partially frontal fatalities	2421	547	- 3	- 4
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)				
Nonfrontal fatalities	3479	762		
Frontal fatalities	5820	1090	14	9
Fatality reduction for driver air bags in all types of crashes:			**9**	**5**

TABLE C-32 - **DRIVERS WITH 40-57 PERCENT EXPECTED BELT USE**
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS WITH 40-57 PERCENT EXPECTED BELT USE,
BASED ON THEIR STATE, ALCOHOL STATUS, VEHICLE AGE AND THE CALENDAR YEAR

LIMITED DATA SET: MAKE-MODELS THAT HAD MANUAL OR AUTOMATIC 3-POINT BELTS
AND ADDED DRIVER AIR BAGS WITHOUT CHANGING THE BELT SYSTEM,
EXCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
	PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)		
Nonfrontal fatalities	516	305	
Purely frontal fatalities	572	202	40
	(statistically significant difference: $\chi^2 = 22.44$)		
	PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)		
Nonfrontal fatalities	516	305	
Partially frontal fatalities	439	213	18
	(not a statistically significant difference: $\chi^2 = 3.20$)		
	ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)		
Nonfrontal fatalities	516	305	
Frontal fatalities	1011	415	31
	(statistically significant difference: $\chi^2 = 15.50$)		

Fatality reduction for driver air bags in all types of crashes: 20 percent

TABLE C-33 - **DRIVERS WITH 40-57 PERCENT EXPECTED BELT USE**
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS WITH 40-57 PERCENT EXPECTED BELT USE, BASED ON THEIR STATE, ALCOHOL STATUS, VEHICLE AGE AND THE CALENDAR YEAR

EXTENDED DATA SET: ALL 1985-95 CARS WITH DRIVER AIR BAGS AND 3-POINT BELTS VS. ALL 1985-95 CARS WITH 3-POINT BELTS ONLY, INCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**	
			Observed	**Adjusted**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)				
Nonfrontal fatalities	5127	548		
Purely frontal fatalities	5649	369	39	33
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)				
Nonfrontal fatalities	5127	548		
Partially frontal fatalities	3943	383	9	8
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)				
Nonfrontal fatalities	5127	548		
Frontal fatalities	9592	752	27	22
Fatality reduction for driver air bags in all types of crashes:			**17**	**13**

TABLE C-34 - **DRIVERS WITH 0-40 PERCENT EXPECTED BELT USE**
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS WITH 0-40 PERCENT EXPECTED BELT USE, BASED ON THEIR STATE, ALCOHOL STATUS, VEHICLE AGE AND THE CALENDAR YEAR

LIMITED DATA SET: MAKE-MODELS THAT HAD MANUAL OR AUTOMATIC 3-POINT BELTS AND ADDED DRIVER AIR BAGS WITHOUT CHANGING THE BELT SYSTEM, EXCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

	Cars with Belts Only	**Cars with Driver Air Bags**	**Frontal Fat. Red. for Air Bags (%)**
PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)			
Nonfrontal fatalities	466	193	
Purely frontal fatalities	493	165	19
(not a statistically significant difference: $\chi^2 = 2.95$)			
PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)			
Nonfrontal fatalities	466	193	
Partially frontal fatalities	442	160	13
(not a statistically significant difference: $\chi^2 = 1.15$)			
ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)			
Nonfrontal fatalities	466	192	
Frontal fatalities	935	325	16
(not a statistically significant difference: $\chi^2 = 2.68$)			

Fatality reduction for driver air bags in all types of crashes: 11 percent

TABLE C-35 - **DRIVERS WITH 0-40 PERCENT EXPECTED BELT USE**
EFFECTIVENESS OF DRIVER AIR BAGS BASED ON REDUCTION OF
FRONTAL FATALITIES RELATIVE TO NONFRONTAL FATALITIES

ANALYSIS OF FATALLY INJURED DRIVERS WITH 0-40 PERCENT EXPECTED BELT USE,
BASED ON THEIR STATE, ALCOHOL STATUS, VEHICLE AGE AND THE CALENDAR YEAR

EXTENDED DATA SET: ALL 1985-95 CARS WITH DRIVER AIR BAGS AND 3-POINT BELTS
VS. ALL 1985-95 CARS WITH 3-POINT BELTS ONLY,
INCLUDING MAKE-MODELS THAT GOT ABS AT THE SAME TIME AS AIR BAGS

			Frontal Fat. Red. for Air Bags (%)	
	Cars with Belts Only	**Cars with Driver Air Bags**	**Observed**	**Adjusted**
		PURELY FRONTAL CRASHES (12:00 principal impact; most harmful event is not a rollover)		
Nonfrontal fatalities	4091	326		
Purely frontal fatalities	5000	261	34	28
		PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact, excluding purely frontal crashes)		
Nonfrontal fatalities	4091	326		
Partially frontal fatalities	4078	272	16	15
		ALL FRONTAL OR PARTIALLY FRONTAL CRASHES (10:00-2:00 principal and/or initial impact)		
Nonfrontal fatalities	4091	326		
Frontal fatalities	9078	533	26	21
Fatality reduction for driver air bags in all types of crashes:			**18**	**14**

APPENDIX D

BELT USE OBSERVED IN STATE SURVEYS, 1990-94

(Source: NHTSA, Office of Occupant Protection)

State	Observed On-The-Road Belt Use by Drivers and Right-Front Passengers (%)					1992 Population
	1990	1991	1992	1993	1994	
Alabama	42	53	58	55	55	4,140,000
Alaska	45	66	66	69	69	590,000
Arizona	55	65	73	73	60	3,830,000
Arkansas	34	52	55	55	51	2,400,000
California	67	71	70	83	83	30,870,000
Colorado	50	51	50	53	54	3,470,000
Connecticut	59	61	71	71	72	3,280,000
Delaware	45	42	70	68	63	690,000
D.C.	49	49	59	62	62	590,000
Florida	53	60	57	62	61	13,490,000
Georgia	41	54	51	57	57	6,750,000
Hawaii	85	85	83	84	84	1,160,000
Idaho	35	45	53	59	61	1,070,000
Illinois	48	51	65	67	68	11,630,000
Indiana	47	52	56	56	56	5,660,000
Iowa	61	68	71	73	73	2,810,000
Kansas	58	64	70	70	70	2,520,000
Kentucky	32	48	41	40	58	3,760,000
Louisiana	39	37	47	48	50	4,290,000
Maine	35	35	36	36	36	1,240,000
Maryland	68	72	75	72	69	4,910,000
Massachusetts	28	35	31	34	47	6,000,000
Michigan	51	64	54	64	66	9,440,000
Minnesota	47	52	53	55	57	4,480,000
Mississippi	22	32	24	25	43	2,610,000
Missouri	54	54	70	70	68	5,190,000

Observed On-The-Road Belt Use
by Drivers and Right-Front Passengers (%)

State	1990	1991	1992	1993	1994	1992 Population
Montana	64	67	71	71	69	820,000
Nebraska	33	33	33	54	63	1,610,000
Nevada	38	68	63	70	71	1,330,000
New Hampshire	52	49	50	51	54	1,110,000
New Jersey	50	58	68	71	64	7,790,000
New Mexico	59	67	66	75	79	1,580,000
New York	66	68	69	72	73	18,120,000
North Carolina	60	60	70	80	81	6,840,000
North Dakota	28	30	30	30	32	640,000
Ohio	41	50	58	62	62	11,020,000
Oklahoma	37	37	44	47	45	3,210,000
Oregon	50	70	72	73	77	2,980,000
Pennsylvania	56	60	63	68	72	12,010,000
Rhode Island	29	28	32	32	58	1,010,000
South Carolina	49	60	53	59	64	3,600,000
South Dakota	26	33	42	26	40	710,000
Tennessee	43	51	58	58	60	5,020,000
Texas	68	68	69	69	71	17,660,000
Utah	39	45	50	50	53	1,810,000
Vermont	39	40	47	54	68	570,000
Virginia	54	58	72	73	72	6,380,000
Washington	55	69	73	78	81	5,140,000
West Virginia	43	43	34	52	58	1,810,000
Wisconsin	52	58	59	64	64	5,010,000
Wyoming	26	66	66	67	70	470,000
National Average (Population-Weighted)	**53.09**	**58.76**	**61.43**	**65.66**	**66.96**	