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Regulatory and Trade
Counsellors

September 17, 1997

The Honorable Frank W. Hunger
Assistant Attorney General
Civil Division
Room 3143
Department of Justice
Tenth Street and Constitution Avenue, N.W.
Washington, DC 20530

RE: NHTSA Proposed Air Bag Deactivation Rule; Docket No. 74-14; Notice 107

Dear Mr. Hunger:

I would like to call your attention to a Federal regulation under development which would:

- Violate President Clinton's Executive Order 12988 on Civil Justice Reform; and

- Create long-term complex litigation which would needlessly result in further overloading of the Federal court system.

The National Highway Traffic Safety Administration (NHTSA) has issued a Notice of Proposed Rulemaking that would permit vehicle owners to deactivate the driver and/or passenger air bag on request, provided that a fact sheet was read, warning signs installed in the car and an authorization form signed by the owner. The proposed form includes a liability waiver to be signed by the vehicle owner. There are several key deficiencies with regard to the proposed liability waiver which would result in significant litigation in state and federal courts.

1. The proposed waiver would not shield vehicle owners, repair businesses, and manufacturers from litigation under state common law; and

2. The proposed waiver does not even attempt to shield manufacturers from liability under Federal law.

Attached is a legal opinion prepared by Maynard, Cooper & Gale, P.C. of Birmingham, Alabama. The opinion clearly documents that, even with a signed waiver, there is a very serious risk that manufacturers, dealers and vehicle owners would be held liable under Alabama common law in the event of accidents following deactivation of an air bag. The magnitude of awards in Alabama is staggering, please refer to Exhibit C of the legal opinion.

I would note, and the legal opinion points out, that Congress specifically stated that "compliance with a motor vehicle safety standard ... does not exempt a person from liability at common law." If compliance with a Federal safety standard is not sufficient protection against suit under common law than surely deactivating a Federally-mandated safety device likely would not be exempted from potential liability under common law.

We have not researched the laws of other states, but we suspect that the Alabama situation will be applicable in many, if not most, other states.

The bottom line is that the proposed regulation will likely result in significant numbers of new cases filed in both state and federal courts. Every person injured in a vehicle in which the air bag has been deactivated is a potential plaintiff, even if the deactivation was performed properly and in a non-negligent manner. The taxpayers will have to pay for the increased resources which will have to be devoted to the justice system, and consumers will have to pay for the increased costs incurred by vehicle and component manufacturers, vehicle dealers and other repair businesses in defending a multitude of lawsuits. Vehicle owners also will be the target of such litigation (which likely will drive up personal insurance costs).

Executive Order 12988: Civil Justice Reform

President Clinton signed Executive Order 12988 on February 5, 1996 in order to promote increased efficiency in Federal courts and to reduce needless litigation. Section 3 of the Order explicitly directs Federal agencies to "...Promulgate

Regulations Which Do Not Unduly Burden the Federal Court System." However, by:

- Allowing for the deactivation of a Federally-mandated safety device without a showing of case-specific cause or need to deactivate the device; and

- Using a waiver system which would not shield parties from liability under common law;

NHTSA would be creating a regulation which would result in needless litigation in Federal court in violation of the Executive Order.

It is important to note that the regulation is, in itself, needless, i.e. the result of the regulation, deactivation of air bags, can be efficiently accomplished when justified under current NHTSA procedures. The only real purpose of the regulation would be to reduce the NHTSA resources used to administer the current petition-based air bag deactivation process.

We conclude that the Department of Justice should conduct a formal review of this regulation under Executive Order 12988 prior to its submission to OMB under Executive Order 12866. I would like to arrange a meeting with you at your earliest convenience so that we can discuss this issue to ensure that the proposed regulation does not become yet another needless burden on Federal courts.

Sincerely,

Jim J. Tozzi
Director

Attachment

Harvard Center for Risk Analysis

September 30, 1997

Senator Dirk Kempthorne
Committee on Environment and
Public Works
United States Senate
Washington, D.C.

Dear Senator Kempthorne:

I was encouraged to learn of your recent legislative effort to enhance the design of future airbag systems by prohibiting the use of unbelted dummies in the safety compliance tests used by the National Highway Traffic Safety Administration. As you know, the use of an unbelted dummy in the government's compliance test has played a perverse role in airbag design by inducing vehicle manufacturers to produce airbag systems that deploy with more speed and force than is necessary to protect properly belted adults and young children. I support your legislative effort to focus NHTSA and industry efforts toward providing enhanced safety for belted adults and fewer risks to children. I would also like to suggest some additional steps that could be taken by Congress to enhance and refine the effort that you have initiated.

WHY WE SHOULD FOCUS ON PROTECTING THE BELTED ADULT

Although the airbags produced under NHTSA's unbelted compliance test have already saved thousands of lives, it is becoming increasingly clear that those lives could have been saved with less aggressive designs that would have inflicted fewer and less severe injuries on young children as well as belted adults. For both philosophical and practical reasons, it is constructive to focus the energies of regulators and the private sector on improvements in occupant-restraint design that enhance the safety of belted occupants. Please consider both of these arguments.

The philosophical argument is that the safety of adults who fail to obey mandatory safety belt use laws should not be a priority of the federal government, unless providing safety to these occupants can be achieved at little or no economic cost, at no safety disadvantage to the adults who regularly buckle up, and at no safety disadvantage to children. Those who do buckle up and respect the law are in a stronger ethical position to expect and demand further regulatory protections from government.

The practical argument is that the public and private sectors have limited engineering and fiscal resources to devote to auto safety efforts, such as those now underway around the world to enhance the design of airbag systems. By forcing regulators, suppliers, and manufacturers to focus limited resources on measures to enhance safety for belted occupants, the safety payoffs for the investment of available resources will be enhanced. This argument may seem counterintuitive, since the unbelted drivers are most at risk and may currently be involved in

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more crashes, but long-term trends in belt use need to be considered.

Safety belt use rates among American adults have increased from 10% in 1980 to roughly 60% in 1996. It is reasonable to expect that they will continue to increase in the decade ahead. The vehicles produced in the year 2,000 will be on the market for 10 to 20 years, when belt-use rates may begin to approach the high levels that have already been achieved in many other developed countries around the world. Even among high-risk teenage drivers, who appear to be reaping significant benefits from current airbag designs, behavioral norms are gradually changing. Safety belt-use rates among teenagers in the year 2010 are likely to be much higher than they are today precisely because these children will have been raised with different norms toward safety belt use than today's teenagers and parents have been.

SUGGESTIONS FOR ENHANCING NHTSA'S APPROACH TO CHILD PROTECTION

As you consider refining your legislative approach to the occupant-restraint issue, I would like to recommend additional steps that may strengthen your effort. Some would entail subtle modifications to your occupant-restraint amendment while others would entail more emphasis on encouraging NHTSA to explore new strategies aimed at protecting children in crashes.

First, your amendment should be clarified to permit NHTSA to use unbelted, out-of-position child dummies in future amendments to FMVSS 208. The retention of such authority might encourage introduction of "child-friendly" airbag designs, with or without such a standard. In my professional judgment, which is certainly aided by the benefit of hindsight, it has been a mistake to deploy airbags on the passenger side of vehicles in crashes where young children are occupying the front seat. If it were technically feasible, NHTSA should retain the authority to write a performance standard aimed at protecting children (restrained or unrestrained) through use of an unbelted child dummy that might be placed "out of position" in the compliance test.

In other words, in the case of childhood protection, I think there is merit in making an exception to both the philosophical and practical objections to the use of unbelted dummies in compliance tests. The safety of young children (unrestrained as well as restrained) should be a priority of government because such children are more vulnerable in crashes than adults and less capable than adults of protecting themselves. I suspect, based on conversations with Gary Smith, that you did not intend to preclude use of unbelted child dummies in future standards but it is my fear that the current language of your amendment could be interpreted in such a restrictive fashion. I do agree that unbelted adults should not be permitted in the compliance tests and I concur with your decision to allow belted adult dummies of different sizes and positions to be used in future standards.

Second, I recommend that you take appropriate steps to make sure that NHTSA takes seriously the recommendations of NTSB to promote laws in each state aimed at requiring children under the age of 13 to ride in the back seat when such a seat is available (subject to medical exceptions) and be properly restrained. Rhode Island has recently taken a modest step in this direction by requiring children under the age of six to ride in the back, but primary enforcement of this law needs to be added in the future. Grants and financial incentives should be made available to states that are pioneers in this area. Our Center's national survey of licensed drivers in America (enclosed) indicates that the vast majority of citizens (including parents with young children) would support a legal requirement that children be seated in the back and be properly restrained.

Currently, NHTSA and the states are not even collecting observational data on how frequently children in each state ride in the front seat. Without such data, it is not clear how NHTSA intends to make measurable progress on this crucial issue that has been highlighted by NTSB. As an attachment to this letter, I have enclosed some information that our Center shared with NHTSA on this point, as well as the written response we received from NHTSA Administrator Ricardo Martinez. Based on this letter and conversations with career staff at NHTSA, I am convinced that NHTSA lacks both the commitment and resources to get serious about child seating policy, a situation that can only be corrected by congressional action.

For your information, I have also enclosed a proposal that our Center developed to create community-based educational programs aimed at encouraging children to ride in the back seat. You may be interested to know that we have not yet been successful in getting NHTSA interested in this proposal. Regardless of what you may think about child-seating laws, community-based educational efforts will be critical to making sure that owners of resold cars with passenger -side airbags take appropriate steps to protect their children from airbag deployment in the years ahead. Much of the educational effort to date has been directed at the original owners of vehicles, yet we know that owners of used cars, who are often less aware of safety issues, are likely to allow children to ride unrestrained in the front seat.

The safety advantages of the rear seat are substantial. Recently, the Insurance Institute for Highway Safety quantified the intrinsic safety advantages of rear seat occupancy for children, as well as the magnification of this advantage attributable to the widespread introduction of passenger-side airbags into cars and minivans. I am hopeful that you will become a congressional champion of the need to develop a new national norm that "kids ride in the back", a norm that can complement the one that is already developing regarding proper use of restraints.

SUMMARY OF SUGGESTIONS

In summary, I am requesting that you take three steps to enhance the federal government's approach to occupant-protection policy. First, I recommend that you persist in your efforts to make sure that future occupant-restraint standards focus the energies of regulators and the private sector on improving the protection provided to the belted adult. A side benefit of this effort is likely to be airbag designs that are less aggressive and therefore less injurious to children. Second, I recommend that you refine your recent amendment to make sure that the government is clearly permitted to use an unrestrained child dummy in future compliance tests, if that appears to be a technically feasible and cost-effective approach to enhancing airbag design and child safety. Even if educational and legal approaches are wildly successful, it is realistic to expect a significant number of unrestrained children riding in the front seat during the next 20 years. Third, I recommend that you look into what NHTSA is doing in response to NTSB's recommendations about child-seating policy and take steps to make sure that NHTSA gives adequate priority to the child-seating issue.

Thank you in advance for your consideration of these issues. I have appreciated the opportunity to discuss this matter with Gary Smith, who has been a patient listener as well as an articulate advocate of your point of view. Please do not hesitate to contact me if there is anything I can do to enhance your efforts or elaborate on these issues. I am certainly willing to meet with you and/or your staff if you feel such a meeting would be worthwhile.

Sincerely,

John D. Graham

John D. Graham, Ph.D.
Director

cc: Ricardo Martinez, M.D.
James Hedlund, Ph.D.
✓ Jerry Mande

U.S. Department of Transportation
National Highway Traffic Safety Administration

Administrator

**400 Seventh Street, S.W.
Washington, D.C. 20590**

to ABWG

SEP 16 1997

John D. Graham, Ph.D.
Harvard Center for Risk Analysis
Harvard School of Public Health
718 Huntington Avenue
Boston, Massachusetts 02115

Dear Dr. ~~Graham~~ John:

Thank you for your letter and your preliminary report, *Kids at Risk: Where American Children Sit in Passenger Vehicles*. Your results are interesting and I have passed them on to the appropriate staff here to consider as we move forward on the issue of getting kids to ride in the back seat.

Your suggested action steps are appreciated. As you are probably aware, at this time we cannot require states to submit annual data on seat belt use, child safety seat use, or seating position. States continue to struggle to collect these data. We are currently working with Congress on a state incentive program for primary seat belt laws in conjunction with the President's Initiative to Increase Seat Belt Use Nationwide. We will continue to push for upgraded child passenger safety laws in the states, though it is uncertain if Congress will consider another occupant protection incentive program next year. The agenda for the National Association of Governors' Highway Safety Representatives (NAGHSR) Annual Meeting next week is already set, but my staff talked with NAGHSR Executive Director Barbara Harsha about your idea and we have been told it will be considered as an agenda item next year. This year there is a session about older child passengers and I am confident the subject will be raised during that discussion.

I agree with you that getting kids in the back seat is crucial, regardless of other air bag issues. I look forward to talking with you the next time you are in town.

Sincerely,

Ricardo Martinez, M.D.

HARVARD CENTER FOR RISK ANALYSIS

August 27, 1997

Ricardo Martinez, M.D.
Administrator
National Highway Traffic Safety Administration
400 7th St. SW
Washington, D.C. 20590

Dear Ricardo:

RE: GETTING KIDS IN THE BACK SEAT

The growing body of data on the risks that passenger airbags pose for children has been a persistent source of concern to everyone in the safety community. As the 30 million vehicles with passenger bags are resold over the next 10 to 20 years, it is quite possible that the gravity of the childhood mortality problem will worsen. The purpose of this letter is to share some ideas about how we might take some useful steps toward protecting children from passenger bags. An important part of the solution is a redoubling of our efforts to increase the rate of proper child restraint use but there are real limits to what can be achieved in this area.

I have been encouraged by the aggressive educational efforts undertaken by NHTSA and the private sector, particularly those begun in the fall of 1995 that highlighted the rear seat as the safest location for children. The National Transportation Safety Board has also played an important role with its recent recommendation that all 50 states consider enactment of amendments to their child passenger safety laws requiring children under the age of 13 to ride in the rear seat if such a seat is available. Rhode Island has recently passed a legal requirement that children under age six be seated in the rear, although it is not yet clear whether this law will be enforced rigorously. National education campaigns are important, but it is now apparent that aggressive educational and enforcement efforts will be needed in each of the 50 states if the risks of passenger-side airbags to children are to be minimized through changes in where kids sit.

In order to document the extent of the behavioral changes that are required, we have analyzed fatal crash data for the years 1985-1996 to determine where children (dead or surviving) were seated. An interesting feature of this study (enclosed) is a ranking of the 50 states according to the percentage of children who were riding in the front seat when fatal crashes occurred. Our key findings are that (1) about a third of the children (32.5%) were in the front seat, (2) this percentage declined gradually over the 12 year period among infants and toddlers but not among older children, (3) an unused rear seat was available over 90% of the time, and (4) there were significant differences among the states in child seating behaviors. The "best" states were Hawaii, Vermont, Rhode Island, New York, and Montana; the "worst" were Massachusetts, Mississippi, Oklahoma, North Dakota, and Kentucky. We understand that there are some limitations to the use of fatal crash data for the purpose of documenting child seating behaviors.

In light of our findings of interstate differences, I recommend that NHTSA take some specific steps to increase our understanding of why states are different and devise better data systems to rank states on this issue. First, NHTSA should encourage or require each state to report annually the percentage of children observed riding in the front seat. Roadside observational surveys will be more representative, larger in sample size, and more timely than use of fatal crash data. These data should be supplied on an annual basis, possibly in conjunction with annual safety belt use data. I am aware that the agency has some limited observation surveys underway that include information on child seating behavior but these surveys are not designed to provide data on interstate comparisons. Second, NHTSA should consider working with Congress on some type of incentive grant program aimed at encouraging states to take steps that will increase the percentage of children in the rear seat. We need numerical goals on child seating just as we have used such goals effectively on adult safety belt use. Third, it might be useful for NHTSA to organize a session at the annual meeting of the Governors Highway Safety Representatives to elicit information on what states are currently doing in this area and what strategies seem to work in getting kids in the back seat. Perhaps such efforts are already underway.

As you know, our Center also remains quite interested in community-based intervention trials as a tool to determine whether it is feasible to induce rapid and substantial changes in child seating behaviors. We are beginning to work with CDC and some people on the Hill on a funding strategy for community-based projects. We are targeting fiscal year 1999. If you would like NHTSA to play a significant role in this activity, please don't hesitate to contact me.

I know you must be very frustrated that the controversy about disarming airbags is consuming so much time and energy. I agree that something must be done on choice but the more important challenge is to get kids in the back seat with proper restraint. The safety payoffs from that activity will, in my opinion, prove to be more important than what can be achieved through manual cut-off switches or the freedom to disarm airbags.

I hope to see you again the next time I am in D.C. Your thoughts on these issues would be appreciated but I understand how busy you are these days.

Sincerely,

John D. Graham

John D. Graham, Ph.D.
Director

cc: James Hedlund
Congressman Frank Wolf
Mike Finkelstein
Barry Felrice
Harry Teeter

KIDS AT RISK:

WHERE AMERICAN CHILDREN SIT IN PASSENGER VEHICLES

August 26, 1997

Preliminary Report: Released for Public Comment

Roberta Glass, Research Specialist, Harvard School of Public Health, 718 Huntington Avenue, Boston, MA 02115.

John D. Graham, Professor of Policy and Decision Sciences, Harvard School of Public Health, 718 Huntington Avenue, Boston, MA 02115.

Acknowledgments: This research was supported in part by the Harvard Center for Risk Analysis. We thank Sue Goldie and Maria Segui-Gomez for helpful comments.

ABSTRACT

The risks that passenger-side airbags pose for children has caused renewed interest in where children should sit in motor vehicles. This study examines where children (dead or surviving) were sitting in passenger vehicles when fatal crashes occurred in the United States during the years 1985-1996. The major findings are that (1) roughly one-third (32.5%) of children under the age of 13 in cars and minivans were seated in the front seat; (2) this percentage was higher for infants (45.4%) than it was for toddlers (31.8%), young children (29.6%), or subteens (33.8%); (3) this percentage was larger (55.9%) when children are the only passengers in the vehicle than when at least one adult or teenage passenger is in the vehicle (17.3%); and (4) this percentage is larger among children in light trucks (58.2%) than among children in passenger cars and minivans (32.5%). Over the 12-year period analyzed, the percentage of children in the front seat has declined steadily among infants and toddlers but not for young children and subteens. The states with the highest percentage of children in the front seat were Massachusetts (40.0%), Mississippi (39.8%), Oklahoma (38.2%), North Dakota (37.4%), and Kentucky (37.2%); those with the lowest percentages were Hawaii (24.0%), Vermont (24.6%), Rhode Island (26.2%), New York (27.3%), and Montana (27.4%). When a child was seated in the front, the rear seat was completely empty in 65% of the crashes involving cars and minivans. The rear seat had three or more passengers less than 4 percent of the time. More systematic study of child seating behaviors is recommended.

INTRODUCTION

Based on post-crash investigations, the National Highway Traffic Safety Administration (NHTSA) has determined that, from January 1989 to August 1997, 44 children under age 13 were killed by passenger-side airbags in crashes that normally would not have been fatal (NHTSA Web Site, 1997). Overall, it appears that the installation of passenger-side airbags has caused a net increase in fatality risk to children, although the various estimates of the magnitude of the increase are 21% (Ferguson, 1996), 40% (Braver et al, 1997), and 28% to 88% (Kahane, 1996). Most of the risk to children has been incurred by infants who were placed in rear-facing restraints in front of the airbag housing or by children who were unrestrained or improperly restrained (NTSB, 1996). However, there have been cases reported where properly restrained children have been killed or seriously injured by passenger-side airbag deployments (NTSB, 1996; O'Donnell, 1996).

Future airbag systems may be redesigned in order to reduce the risk of children. The depowered airbags now being introduced in the fleet should reduce the severity of injuries to children (NHTSA, 1997). Higher deceleration thresholds for airbag deployment and the introduction of dual-stage inflators may reduce both the number of deployments and the aggressivity of deployments in relatively low-speed impacts. Sensor technology may also be employed to suppress deployment entirely if young children are detected in the front-right seat.

As promising as technological innovation may prove to be, it will do nothing for children riding in the 30 million vehicles in the United States that were sold with passenger-side airbags from 1989 through 1996. Another 20-30 million such vehicles are in the pipeline and can be expected to be used by multiple owners over the next 10 to 20 years. Recognizing the need to protect children in the existing fleet, NHTSA has recommended since late 1995 that infants and young children be seated in the rear seat and be restrained properly. The National Transportation Safety Board has recently taken a stronger step by recommending that state legislatures amend child passenger safety laws to require children under the age of 13 to be seated in the rear seat if a seat is available (NTSB, 1997). Rhode Island has recently adopted such a law for children under the age of six; several other states are considering similar legislation.

It is well established that the rear seat is generally safer than the front seat (Evans and Frick, 1988). Recent studies have demonstrated that this safety advantage of the rear seat is significant for children (Hertz, 1996; Braver et al, 1997). The rapid penetration of passenger-side airbags into the fleet makes it particularly important that vulnerable occupants such as small children be seated in the rear and be properly restrained (Rivara et al, 1997).

The purpose of this article is to provide baseline information on where American children have been sitting in passenger vehicles from 1985 through early 1996, roughly the period prior to the recent public interest in child seating position fueled by the airbag controversy. We focus on children in different age groups in each of the 50 states. We intend to update this analysis in future years in order to determine whether child seating patterns are changing in the United States in response to concern about passenger-side airbags.

PRIOR LITERATURE

The U.S. government does not regularly monitor the seating patterns of children through the most direct and reliable method: roadside and shopping-center observation. Although for several years NHTSA collected this information annually in 19 U.S. cities, this effort was terminated in 1991. Under NHTSA supervision, each of the 50 states now reports information on rates of safety belt use to the federal government, but the states are not required to report consistent and complete information on where children sit in passenger vehicles. NHTSA recently launched a national survey that includes some observational data on the seating behavior of children but such data are not yet publicly available and will not be extensive enough to permit interstate comparisons of where children sit in vehicles.

The Crashworthiness Data System (CDS) was used by Edwards and Sullivan (1997) to examine the seating behaviors of children involved in passenger car crashes severe enough that the car was not driveable. The study found that children were more likely to sit in the front seat if they were the only passenger, the oldest passenger, or riding with an unrestrained driver. Overall about 39% of child passengers under thirteen years of age were riding in the front seat, and only 3.5% of those children had no rear seat available. When a child was the only passenger, 62% of infants, 60% of toddlers (1 to 4 year olds), and 93% of subteens (5 to 12 year olds) were seated in the front. When a child was accompanied by other passengers, 49% of infants, 31% of toddlers, and 39% of subteens were seated in the front.

Data And Methods

The Fatal Accident Reporting System (FARS) is a census of all motor vehicle crashes in the United States that result in at least one fatality. Among other variables, information on the age and seating position of both dead and surviving occupants is recorded.

For the years 1985- June 1996, we identified each child under the age of 13 who was recorded in FARS to have been seated in a passenger vehicle when a fatal crash occurred. The time period was chosen in order to precede the massive media publicity regarding the dangers of passenger-side airbags, thus providing an interesting baseline portrait of child seating behaviors in fatal crashes in the United States.

Passenger cars, mini-vans, and light trucks were included in the analysis. Data are presented separately for passenger cars and minivans versus light trucks because some light trucks do not have rear seats. Children were excluded from the analysis if they were recorded as the driver of the vehicle or if their seating position was unknown. Children were grouped by age into four categories: less than 1 year of age for infants, 1 to 3 years old for toddlers, 4 to 8 years old for young children, and 9 to 12 years old for subteens. Separate counts were made for each of the 50 states.

RESULTS

For the entire twelve-year period, we identified 50,081 children under the age of 13 who were occupants of passenger cars or minivans and involved in fatal crashes in the United States. Another 14,629 children under the age of 13 who were occupants of light trucks were also involved in fatal crashes during this period. Overall, the percentage of children riding in the front seat was 32.5% for passenger cars/minivans and 58.2% for light trucks.

If there is no adult or teenage passenger in the vehicle, it is much more likely that a child under the age of 13 will be found in the front seat. In Table 1, for example, it is shown that the percentage of children riding in the front seat of passenger cars/minivans is 55.9% when there are no adult or teenage passengers versus 17.3% when there is at least one passenger in the vehicle over the age of 12.

A shortage of rear seating capacity is not, as Figure 1 indicates, a valid explanation for the substantial percentage of children riding in the front seat. When children were occupying a front seating position, the distribution of occupied rear seats was 0 (64.7%), 1 (21.2%), 2 (9.9%), and 3 or more (3.3%) for passenger cars/minivans and 0 (90.2%), 1 (6.0%), 2 (2.6%), and 3 or more (1.2%) for light trucks. It should be noted that the light truck category includes vehicles with no rear seats in the 0 seat category, thus artificially inflating the percent of light trucks with no rear seats occupied and deflating the percents of 1, 2, and 3 or more seats occupied. However, it is apparent that more than 95% of the children recorded in the front seat of minivans and cars could have been riding in a rear seat (unless non-human cargo imposed additional restrictions).

As indicated in Table 1, the percentage of children seated in the front seat varies by age of child. For infants, toddlers, young children, and subteens the percentage riding in the front seat was 45.4%, 31.8%, 29.6%, and 33.8%, respectively. The annual data by age of child are plotted in Figure 2 to provide an indication of national trends. There has been a steady, gradual decline in the numbers of infants and toddlers riding in the front seat. No such trend is apparent for children in the two older age groups.

We examined the interstate variation in child seating behaviors. Table 2 reports the percentage of children in the front seat of passenger cars/minivans by state for the twelve years combined. States are ranked from the highest to the lowest on the percentage of children seated in the front seat. The percentage varies from a low of 24.0% in Hawaii to a high of 40.0% in Massachusetts. When children are traveling with a teen or an adult passenger the percentage of children in the front seat varies from 2.9% in Alaska to 26.6% in South Dakota. When there is no teen or adult passenger, the percent of children riding in the front seat is much higher, ranging from 39.4% in Hawaii to 84.6% in North Dakota. Table 3 presents similar data for children riding in light trucks. Controlling for vehicle type, presence of a teen or adult passenger, calendar year, age category, and number of children in the vehicle, the Mantel-Haenszel test of general association found that there was a difference in the proportion of children seated in the front across states (χ^2=345.6, p=.001).

Next we grouped the states by geographic region. As shown in Table 4, the percent of children seated in the front was 47% in southern states; between 43% and 44% in the midwestern, mountain, Pacific west, and south Atlantic states; and 38% in the northeast. The association between seating behavior and region was significant (χ^2=202.6, p=.001) controlling for vehicle type, presence of a teen or adult passenger, calendar year, age category, and number of children in the vehicle.

LIMITATIONS

The data reported here concern child seating behaviors in crash situations that are serious enough to cause at least one fatality (adult or child). These data may not be representative of child-seating behaviors observed via roadside observation or in property-damage crashes.

In order for a crash to be included in FARS, at least one fatality must occur. If children are seated in the front seat when a crash occurs, the chances of a fatality occurring are elevated. For this reason alone, the FARS data will tend to find more children in the front seat than would a database on all crashes (regardless of injury severity). Moreover, if adults involved in fatal crashes are less safety conscious than the average adult and if safety conscious drivers are more likely to have their children ride in the rear seat, then the percentage of children in the front seat may be higher in FARS data than it would be estimated by roadside observation of a random sample of vehicles. If these biases exist, they should not necessarily affect the trends we report, the differences across age groups, or the rankings of the states (assuming that similar biases exist across these categories). There is also an unknown degree of inaccuracy and incompleteness in the child-seating information contained in FARS, particularly among children who survive.

DISCUSSION

Based on the fatal crash data from 1985 to mid 1996, it is apparent that a substantial percentage of children in the United States ride in the front seat when traveling in motor vehicles. This behavior varies to some extent by age of child, vehicle type, the age of other passengers in the vehicle, and region of the country. It is quite clear from the fatal crash data that a shortage of rear seating capacity is not a valid explanation for why children in America ride in the front seat. In prior survey research, it was found that parents in the United States have no consensus viewpoint about precisely when it is safe for children to ride in the front seat (Graham et al, 1997).

Until recently, it was commonly accepted in the United States that this behavior was acceptably safe as long as the child was properly restrained in an appropriate child restraint device or lap/shoulder belt. Interestingly, a different norm developed in continental Europe beginning in the mid-1970s, where it became customary for children under the age of 12 to sit in the rear seat, even if the front passenger seat was not occupied.

When a properly belted 5-year old child, Frances Ambrose of Nashville Tennessee, was killed by a passenger-side airbag in the fall of 1995, the message of America's safety establishment changed. The Airbag Safety Campaign, a national education campaign launched by automakers, suppliers, insurers, and NHTSA, began to emphasize that children should be seated in the back seat and restrained properly. Bills have been introduced in numerous state legislatures that would require young children to ride in the rear seat if a seat is available. Rhode Island has already applied such a legal requirement to children under the age of 6 and the National Transportation Safety Board is urging the Governors of each state to promote such legislation.

The data presented in this paper constitute a comprehensive portrait of what child seating behaviors were in the United States prior to this marked change in the safety community's message about child passenger protection that occurred in late 1995. We plan similar analyses in the years ahead to determine whether concern about passenger-side airbags, as influenced by legislation, the media, and the Airbag Safety Campaign's educational activities, results in an observable change in the seating location of children in motor vehicles -- both in those makes and models that are equipped with passenger side airbags and those that are not.

There is good reason to believe that the child mortality rate in crashes could increase in the next ten years if this educational campaign is not highly effective (NHTSA, 1997). The number of vehicles on the road with passenger-side airbags is growing rapidly and an increasing number of less educated car buyers will soon purchase used vehicles in the resale market that are equipped with passenger-side airbags. It can reasonably be expected that these less educated owners will be more likely than new vehicle owners to allow children to ride in the front seat without proper restraint. These behaviors will cause many more children, who will often slide forward during pre-crash braking, to be placed in close proximity to the explosive forces of rapidly inflating airbags. Given the low deployment thresholds that are typical of current airbag designs, many of these children could be injured or even killed by airbags in crashes that would not otherwise be serious (NTSB, 1996).

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Figure 1 Number of Occupied Rear Seats in Passenger Vehicles with Child Seated in Front, 1985-June 1996 (Fatal Crashes)

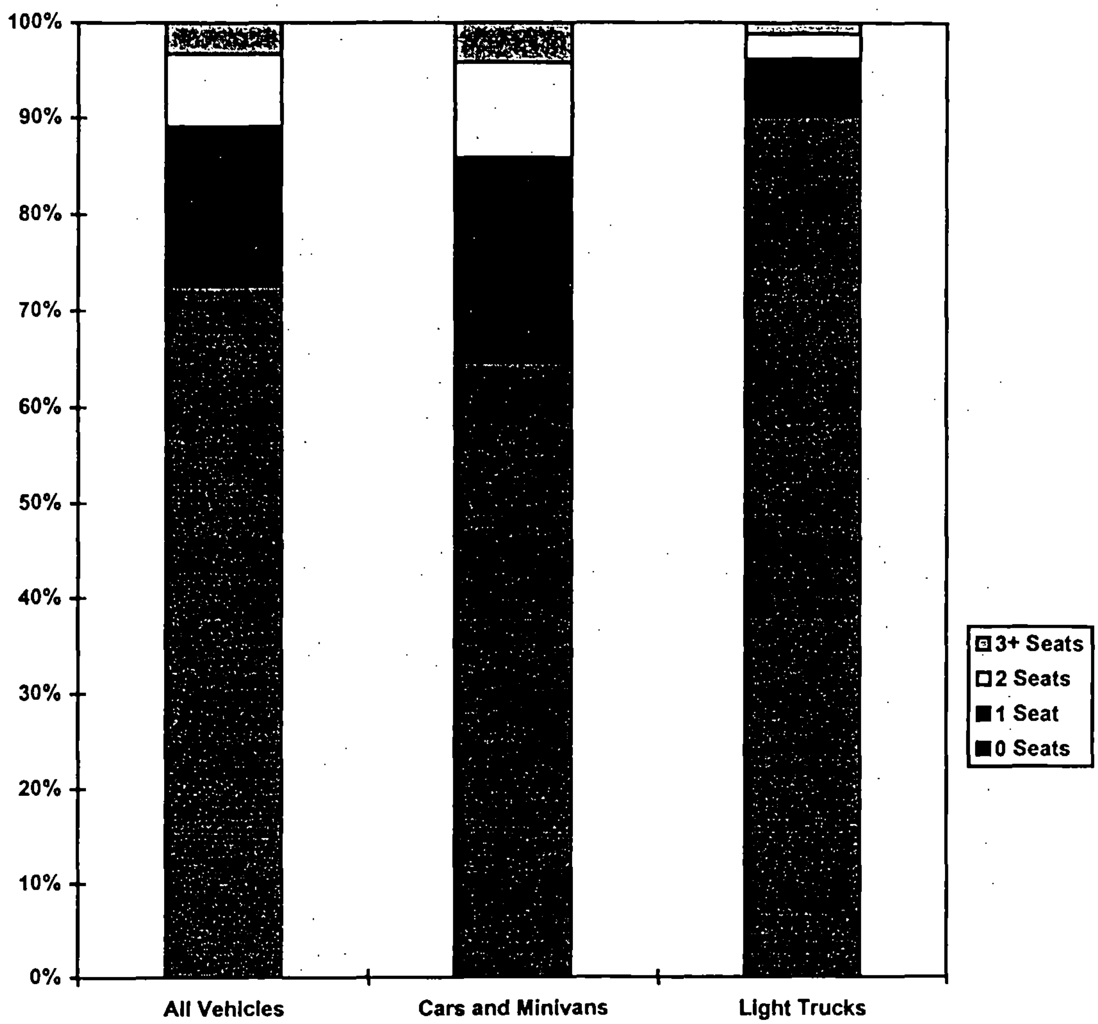

Figure 2 Time Trend for Children Seated in the Front of Cars and Mini-vans by Age Category, 1985-1996

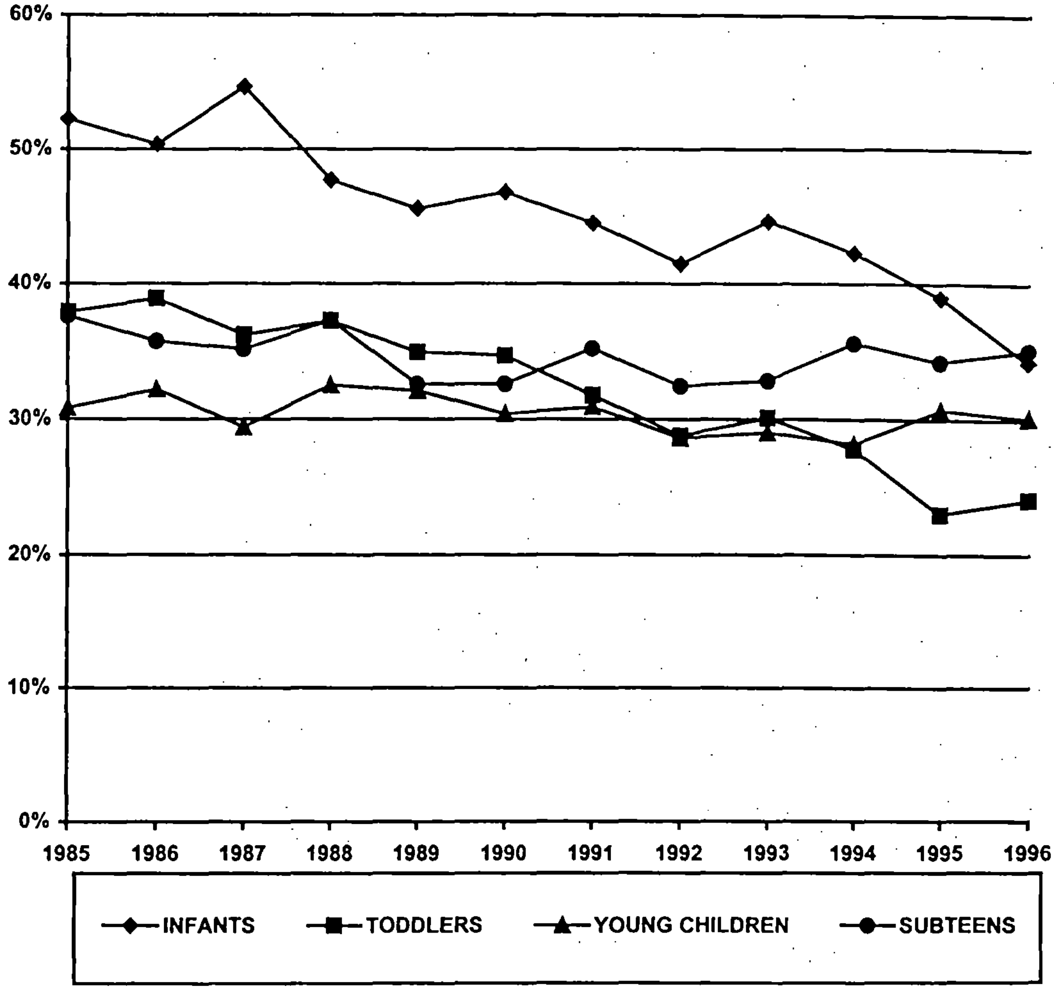

Table 1 Percent of Children Under Age 13 Seated in the Front Row of Cars and Minivans Involved in Fatal Crashes, 1985 - June 1996, by Age Category

State	All Children		Children Traveling with a Passenger Aged 13+		Children Traveling Alone or with Other Children Under Age 13	
	N	Percent in Front Seat	N	Percent in Front Seat	N	Percent in Front Seat
Infant	3752	45.4	2522	38.1	1230	60.3
Toddler	14083	31.8	8695	21.6	5388	48.1
Young	19049	29.6	10974	11.9	8075	53.7
Subteens	13197	33.8	8130	13.5	5067	66.4
Total	50081	32.5	30321	17.3	19760	55.9

Table 2 Percent of Children Under Age 13 Seated in the Front Row of Cars and Mini-vans Involved in Fatal Crashes, 1985 - June 1996, by State

State	All Children			Children Traveling with a Passenger Aged 13 or Older			Children Traveling Alone or with Other Children Aged 12 or Younger		
	N	Percent in Front Seat	Rank	N	Percent in Front Seat	Rank	N	Percent in Front Seat	Rank
AL	1246	35.7	8	779	19.5	10	467	62.7	4
AK	134	28.4	45	69	2.9	51	65	55.4	23
AZ	1237	30.1	39	856	19.5	11	381	53.8	28
AR	710	35.4	9	445	19.8	8	265	61.5	7
CA	5668	29.9	41	3593	15.8	36	2075	54.4	26
CO	660	33.2	22	385	16.4	30	275	56.7	19
CT	309	28.5	44	172	14.5	41	137	46.0	49
DE	159	32.7	27	88	14.8	40	71	54.9	25
DC	43	34.9	11	26	23.1	3	17	52.9	34
FL	3348	32.6	29	2044	17.1	26	1304	56.9	17
GA	1836	36.2	6	1057	21.2	5	779	56.5	20
HI	183	24.0	51	112	14.3	45	71	39.4	51
ID	347	32.0	32	197	18.3	18	150	50.0	45
IL	1649	31.3	34	996	16.9	28	653	53.3	32
IN	1022	34.1	16	567	17.3	24	455	55.0	24
IA	471	34.4	14	255	18.0	19	216	53.7	30
KS	529	33.8	17	308	21.1	6	221	51.6	38
KY	1107	37.2	5	688	21.8	4	419	62.5	5
LA	1021	33.2	21	648	19.4	12	373	57.1	16
ME	220	35.0	10	117	18.8	16	103	53.4	31
MD	791	33.0	24	444	17.3	23	347	53.0	33
MA	190	40.0	1	95	19.0	13	95	61.1	10
MI	2088	31.2	35	1160	14.5	42	928	52.1	36
MN	510	32.5	30	313	17.6	22	197	56.4	21
MS	1122	39.8	2	713	24.0	2	409	67.2	3
MO	1029	33.4	20	628	15.8	37	401	61.1	9
MT	248	27.4	47	162	15.4	38	86	50.0	46
NE	294	32.7	28	155	16.1	32	139	51.1	41
NV	298	27.9	46	189	13.8	47	109	52.3	35
NH	126	30.2	38	74	16.2	31	52	50.0	47
NJ	797	30.4	36	468	16.0	34	329	50.8	43
NM	653	28.6	43	481	17.1	27	172	61.1	11
NY	2071	27.3	48	1239	11.6	48	832	50.7	44
NC	2271	34.8	12	1399	17.7	21	872	62.3	6
ND	99	37.4	4	73	20.6	7	26	84.6	1
OH	1928	33.5	19	1035	17.8	20	893	51.6	37

State	All Children			Children Traveling with a Passenger Aged 13 or Older			Children Traveling Alone or with Other Children Aged 12 or Younger		
	N	Percent in Front Seat	Rank	N	Percent in Front Seat	Rank	N	Percent in Front Seat	Rank
OK	730	38.2	3	396	19.7	9	334	60.2	13
OR	732	30.2	37	455	15.8	35	277	53.8	29
PA	1653	30.0	40	997	14.3	44	656	53.8	27
RI	42	26.2	49	21	9.5	50	21	42.9	50
SC	1051	34.3	15	594	16.5	29	457	57.6	15
SD	191	34.6	13	128	26.6	1	63	50.8	42
TN	1427	36.0	7	827	18.5	17	600	60.2	14
TX	4206	32.3	31	2724	18.9	15	1482	56.8	18
UT	473	29.6	42	314	14.0	46	159	60.4	12
VT	118	24.6	50	74	10.8	49	44	47.7	48
VA	911	33.6	18	527	17.3	25	384	56.0	22
WA	811	31.3	33	449	15.1	39	362	51.4	39
WV	479	32.8	26	322	18.9	14	157	61.2	8
WI	695	32.8	25	366	16.1	33	329	51.4	40
WY	148	33.1	23	97	14.4	43	51	68.6	2
Total	50081	32.5		30321	17.3		19760	55.9	

Table 3 Percent of Children Under Age 13 Seated in the Front Row of Light Trucks Involved in Fatal Crashes, 1985 - June 1996, by State

State	All Children			Children Traveling with a Passenger Aged 13 or Older			Children Traveling Alone or with Other Children Aged 12 or Younger		
	N	Percent in Front Seat	Rank	N	Percent in Front Seat	Rank	N	Percent in Front Seat	Rank
AL	295	65.8	12	156	53.2	14	139	79.9	26
AK	70	48.6	46	44	31.8	46	26	76.9	38
AZ	679	50.5	44	510	40.6	32	169	80.5	22
AR	326	67.8	10	212	58.5	7	114	85.1	11
CA	1942	50.9	42	1302	38.5	37	640	76.1	40
CO	296	54.1	37	190	41.6	30	106	76.4	39
CT	51	60.8	24	21	57.1	8	30	63.3	49
DE	34	47.1	47	24	29.2	47	10	90.0	4
DC	7	85.7	1	5	80.0	1	2	100.0	1
FL	710	62.8	23	425	53.2	15	285	77.2	35
GA	420	63.3	22	223	47.1	21	197	81.7	19
HI	70	37.1	51	42	26.2	49	28	53.6	51
ID	179	49.2	45	117	35.0	42	62	75.8	42
IL	301	56.1	32	165	38.8	36	136	77.2	34
IN	193	69.9	8	102	60.8	6	91	80.2	24
IA	89	70.8	6	44	61.4	5	45	80.0	25
KS	194	64.9	13	106	51.9	16	88	80.7	21
KY	286	72.4	3	142	65.5	2	144	79.2	27
LA	354	63.8	20	232	53.4	13	122	83.6	14
ME	62	56.5	30	37	45.9	24	25	72.0	46
MD	123	38.2	50	83	16.9	50	40	82.5	17
MA	42	71.4	5	16	62.5	4	26	76.9	37
MI	446	53.4	39	242	39.7	34	204	69.6	47
MN	121	70.2	7	53	54.7	11	68	82.4	18
MS	263	67.3	11	155	54.8	10	108	85.2	10
MO	316	68.7	9	166	54.2	12	150	84.7	13
MT	130	58.5	27	82	45.1	25	48	81.3	20
NE	77	63.6	21	39	41.0	31	38	86.8	9
NV	137	51.1	41	90	38.9	35	47	74.5	44
NH	31	64.5	16	14	35.7	41	17	88.2	6
NJ	116	50.9	43	56	37.5	39	60	63.3	50
NM	374	63.9	19	257	56.4	9	117	80.3	23
NY	294	54.1	36	153	34.0	45	141	75.9	41
NC	482	64.3	18	273	46.5	22	209	87.6	7
ND	34	64.7	15	14	28.6	48	20	90.0	3
OH	372	60.5	25	239	48.1	20	133	82.7	15

State	All Children			Children Traveling with a Passenger Aged 13 or Older			Children Traveling Alone or with Other Children Aged 12 or Younger		
	N	Percent in Front Seat	Rank	N	Percent in Front Seat	Rank	N	Percent in Front Seat	Rank
OK	315	64.4	17	177	50.3	17	138	82.6	16
OR	274	54.7	34	173	41.6	29	101	77.2	33
PA	301	58.5	26	138	34.8	43	163	78.5	31
RI	9	44.4	49	5	0.0	51	4	100.0	2
SC	169	75.7	2	93	64.5	3	76	89.5	5
SD	58	53.4	38	30	43.3	27	28	64.3	48
TN	312	64.7	14	171	46.2	23	141	87.2	8
TX	1967	56.4	31	1288	44.7	26	679	78.6	30
UT	245	45.3	48	182	34.1	44	63	77.8	32
VT	32	71.9	4	12	50.0	18	20	85.0	12
VA	223	57.8	28	145	48.3	19	78	75.6	43
WA	306	54.9	33	171	37.4	40	135	77.0	36
WV	208	54.3	35	141	42.6	28	67	79.1	28
WI	187	56.7	29	95	40.0	33	92	73.9	45
WY	107	52.3	40	69	37.7	38	38	78.9	29
Total	14629	58.2		8921	44.8		5708	79.1	

Table 4 Percent of Children Under Age 13 Seated in the Front Row of Vehicles Involved in Fatal Crashes, 1985 - June 1996, by Vehicle Type and Region

State	All Children		Children Traveling with a Passenger Aged 13+		Children Traveling Alone or with Other Children Under Age 13	
	N	Percent in Front Seat	N	Percent in Front Seat	N	Percent in Front Seat
All Vehicles						
Midwest	12440	43.2	6934	28.3	5506	61.9
Mountain	5774	44.5	3782	33.1	1992	66.1
Northeast	6266	37.8	3546	21.6	2720	58.9
Pacific	9317	43.3	5653	30.4	3664	63.2
South Atlantic	12736	44.1	7460	29.2	5276	65.2
South	15008	47.1	9172	33.5	5836	68.5
Cars and Mini-vans						
Midwest	10295	37.5	5835	22.6	4460	57.0
Mountain	3993	34.9	2618	22.6	1375	58.3
Northeast	5401	33.6	3155	18.5	2246	54.8
Pacific	7211	36.4	4408	23.2	2803	57.1
South Atlantic	10668	38.7	6309	23.4	4359	60.7
South	11411	39.3	7083	25.2	4328	62.4
Light Trucks						
Midwest	2145	70.4	1099	58.2	1046	83.1
Mountain	1781	66.0	1164	56.8	617	83.3
Northeast	865	63.8	391	46.0	474	78.5
Pacific	2106	67.1	1245	56.1	861	83.2
South Atlantic	2068	72.2	1151	60.6	917	86.6
South	3597	71.8	2089	61.7	1508	85.7

Harvard Center for Risk Analysis

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March 13, 1997

Embargoed - This information can be released on Monday, March 17, 1997

SURVEY OF AMERICANS SHOWS AIRBAGS ARE MISUNDERSTOOD

Boston - Despite recent news reports that highlight the danger for young children of passenger side airbags, Americans overwhelmingly favor the use of airbags. However, their support is based on a variety of misperceptions about their use and safety. The findings come from a survey reported today by the Harvard School of Public Health.

The survey was designed by investigators of the Center for Risk Analysis at the Harvard School of Public Health. The survey was administered to 1,000 Americans in 48 states by a survey research firm, the weekend of February 28-March 2, 1997. All those surveyed are licensed to drive a motor vehicle.

Almost 60% of respondents are under the mistaken impression that more children have been saved by airbags than have been killed. Although respondents recognized that the airbag can save lives, they were unclear about the scope of injuries, both mild and serious, caused by airbags. Nearly 78% feel that using a seatbelt eliminates the risk of airbag-induced injury, a belief which is shown by studies to be incorrect. Those surveyed are largely unaware that a majority of lives saved by airbags have been among people who were not wearing seatbelts.

A hint of ambivalence about airbags is indicated by nearly 30 % of respondents who, in buying their next vehicle, would be likely to request that the dealer disconnect the airbag system.

Although respondents generally favor the use of airbags, a large majority (71%) would favor a law in their state requiring children under the age of 10 to be seated in the rear seat and buckled. Other findings include that one third or less of those interviewed knew at what speeds airbags release

The survey found that women are developing some doubts about airbags. A smaller percentage of women (35.8% , men 43.9%) favored strongly current airbag regulation and, in the last 3 years, many women (32%) have developed a less favorable attitude toward airbags.

Comments John Graham, lead author on the study, "A startling result of our survey was the lack of consensus in America about when a child is old enough to be seated in the front seat. In Germany and France, all young children under age 10 are required by law to sit in the back seat!"

He continues, "Our findings also indicate public interest in the design of new airbag systems that would suppress or slow airbag deployment when children are at risk."

THE AIRBAG'S TEFLON IMAGE:

A NATIONAL SURVEY OF KNOWLEDGE AND ATTITUDES

Public Forum
Air Bags and Child Passenger Safety
National Transportation Safety Board
Washington, D.C.

Center for Risk Analysis
Injury Control Center
Harvard School of Public Health
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Hold for Release: March 17, 1997

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EXECUTIVE SUMMARY

The Centers for Risk Analysis and Injury Control of the Harvard School of Public Health sponsored a representative survey of 1,000 randomly-sampled Americans regarding their knowledge, perceptions, and attitudes about airbags and passenger safety. The key findings of the survey are summarized below.

KNOWLEDGE

--67.1% of respondents recognize that it is dangerous to place an infant in a rear-facing restraint in the front seat of a vehicle with a passenger-side airbag.

--71.0% of respondents recognize that a driver can be seriously injured or killed by an airbag if the driver is seated too close to the steering wheel.

--68.4% of respondents recognize that more lives of female drivers have been saved by airbags than have been killed by airbags.

MISPERCEPTIONS

--59.9% of respondents are under the (mistaken) impression that the lives of more children have been saved by airbags than have been killed by airbags.

--When asked when it becomes safe for a child to sit in the front seat, fewer than 25% of respondents with children in the home picked age 12 or greater, even though safety experts recommend that children under age 12 sit in the rear seat.

--77.8% of respondents are under the (mistaken) impression that the risk of airbag-induced injury is minimal if a driver wears a seatbelt properly.

--51.3% of respondents are not aware that a majority of the lives that have been saved by airbags have been among people who were not wearing seatbelts.

--74.0% of respondents are not aware that the deployment threshold for airbags has been set by manufacturers at a level equivalent to hitting a cement wall at 12 miles per hour.

ATTITUDES

--70.9% of respondents would favor a law in their state requiring children under the age of 10 to be seated in the rear seat and buckled.

--66.3% of respondents favor the current law requiring all new vehicles to be equipped with dual-front airbags.

--Although 54.0% of respondents state they have the same opinion toward airbags that they did three years ago, there is clear evidence that women are developing less favorable attitudes toward the technology.

--If given the opportunity to do so, 29.0% of respondents, when buying their next vehicle, would be likely to request that the dealer disconnect the airbag system.

--If their next vehicle were equipped with a manual cutoff switch, 33.0% of respondents can imagine circumstances where they would turn the airbag system off at the start of a trip.

CONCLUSION

The survey results suggest that there is a widespread public support for airbags in the United States. However, this support is contingent to some extent on a variety of misperceptions about the technology. There is also substantial public support for policies to reduce the dangers of airbags, such as requiring children under the age of 10 to sit in the rear seat and wear safety belts. The public is also interested in improved airbag systems.

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SURVEY METHODS

The survey instrument was designed by scientists at the Center for Risk Analysis and Injury Control Center at the Harvard School of Public Health. The instrument was administered to a random sample of 1,000 Americans in the 48 contiguous states by Market Facts Inc., a survey research firm based in Chicago, Illinois. The survey was conducted on the weekend of February 28-March 2, 1997.

The sample of respondents was generated through random digit dialing procedures, with three attempts made at each telephone number. A screening question identified whether the respondent was licensed to drive a motor vehicle. The average respondent took 15 minutes to answer the airbag-related questions. A copy of the complete survey instrument is available from the authors upon request. The summary results reported here are for the 933 respondents who are licensed to drive a motor vehicle.

RESPONDENT CHARACTERISTICS

Gender	
Male	51.3%
Female	48.7%

Age	
18-24	9.9%
25-34	19.4%
35-44	24.8%
45-54	19.8%
55-64	12.5%
65+	13.5%

Children in House	
Yes	39.5%
No	60.5%

Race	
White	85.4%
Nonwhite	14.6%

Region of Country	
Northeast	21.0%
Midwest	25.6%
South	34.1%
West	19.3%

Education	
High School or Less	46.1%
College	43.7%
Post-Graduate	10.2%

Primary Vehicle Has Air Bag	
Driver-side only	19.4%
Dual front	19.8%
None	60.3%
DK	0.5%

Family Member Ever Involved in Crash Where Air Bag Deployed	
Yes	6.3%
No	93.5%
DK	0.2%

Self-Reported Belt Use	
Always	70.0%
Most of the time	17.9%
Sometimes	5.2%
Rarely or never	6.9%

KNOWLEDGE ABOUT AIR BAGS AND PASSENGER SAFETY

1. True or False: Air bags are not a danger to an infant in the front seat if the infant is restrained in an approved, rear-facing child restraint device.

Response	All Respondents	Respondents with Kids
True	243 (26.3%)	92 (24.8%)
False	621 (67.1%)	260 (70.3%)
DK	61 (6.6%)	18 (4.9%)

TECHNICAL COMMENT

According to safety experts, the correct answer is "false". Rear-facing infant or child restraints should never be placed in the front seat of a vehicle equipped with passenger-side airbags. A rear-facing restraint placed in the front seat places the child's head and body very close to the airbag housing. When the bag deploys, it can cause the child to suffer severe or fatal brain injury.

Reference

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2. True or False: If a driver is seated too close to the steering wheel, the airbag can cause serious injury or death to the driver in a crash.

Response	Males	Females	Total
True	317 (68.6%)	340 (73.4%)	657 (71.0%)
False	104 (22.4%)	73 (15.8%)	177 (19.1%)
DK	41 (8.9%)	50 (10.8%)	92 (9.9%)

TECHNICAL COMMENT

This statement is true, and is amply supported by both experimental data and investigations of real-world crashes.

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SA Ferguson, "Update in Airbag Performance in the United States: Benefits and Problems," Insurance Institute for Highway Safety, Arlington, VA, Paper Presented to AIRBAG 2,000 Conference, Karlsruhe, Germany, November 1996.

3. True or False: The lives of more female drivers have been saved by air bags than have been killed by air bags.

Response	**Males**	**Females**	**Total**
True	342 (74.0%)	290 (62.7%)	632 (68.4%)
False	70 (15.2%)	86 (18.6%)	157 (16.9%)
DK	49 (10.7%)	85 (18.4%)	134 (14.7%)

TECHNICAL COMMENT

This statement is correct and could also be correctly made for male drivers.

References

SA Ferguson, "Update on Airbag Performance in the United States: Benefits and Problems," Insurance Institute for Highway Safety, Arlington, VA, Paper Presented to Airbag 2,000 Conference, Karlsruhe, Germany, November 1996.

National Highway Traffic Safety Administration, Fatality Reduction by Air Bags: Analyses of Accident Data Through Early 1996, NHTSA Technical Report, DOT HS 808 470, Washington, D.C., August 1996.

AK Lund, SA Ferguson, "Driver Fatalities in 1985-1993 Cars with Airbags," Journal of Trauma: Injury, Infection, and Critical Care, 38;469–475. 1995.

SECTION 2: MISPERCEPTIONS ABOUT AIRBAGS AND PASSENGER SAFETY

1. At what age would you say it is safe for a child to sit in the front seat?

Age in Years	All Respondents	Respondents with Kids
4 or less	141 (15.3%)	59 (16.0%)
5	89 (9.7%)	43 (11.7%)
6	126 (13.6%)	46 (12.5%)
7	58 (6.2%)	29 (7.8%)
8	90 (9.7%)	34 (9.2%)
9	17 (1.9%)	9 (2.5%)
10	144 (15.6%)	54 (14.7%)
11	7 (0.8%)	2 (0.5%)
12	93 (10.0%)	35 (9.4%)
13 or more	97 (10.5%)	49 (13.3%)
DK	62 (6.8%)	9 (2.3%)

TECHNICAL COMMENT

The American people have no consensus belief about when it is safe for children to sit in the front seat of a motor vehicle. Safety experts recommend that children under the age of 12 be seated in the rear seat and properly restrained. In vehicles with passenger-side air bags, this recommendation is especially critical because a restrained child or unrestrained child may slide forward into the airbag's deployment zone during pre-crash braking. In several European countries (e.g., Germany and France), children under the age of 10 or 12 are required by law to be seated in the rear seat.

Reference

National Highway Traffic Safety Administration, Effectiveness of Occupant Protections Systems and Their Use. Third Report to Congress, Washington, D.C., December 1996.

2. True or False: The lives of more children have been saved by airbags than have been killed by airbags.

Responses	**Males**	**Females**	**Respondents with Kids**	**All Respondents**
True	307 (66.4%)	247 (53.4%)	206 (55.7%)	554 (59.9%)
False	107 (23.0%)	166 (35.9%)	128 (34.7%)	273 (29.5%)
Don't Know	98 (10.6%)	49 (10.6%)	35 (9.5%)	98 (10.6%)

TECHNICAL COMMENT

Based on the best available evidence, the correct answer to this statement is "false". We are assuming that "children" are defined, as we intended and believe respondents intended, in the age range of 12 and below. The front-seat death rate for children in cars with passenger-side airbags is elevated (relative to the death rate for front-seat children in cars without passenger-side airbags) for kids of all ages from 0 to 14. The magnitude of the increase in danger to children is not known with any precision and conclusions about the statistical significance of the elevated risk are sensitive to the choice of analytical technique.

Much of the increased danger to children from airbags is attributable to behaviors that must be changed (e.g., allowing children to ride in the front seat unrestrained or placing rear-facing infant restraints in front of the passenger-side airbag). Even if all children were properly restrained, it cannot be stated with confidence that passenger-side airbags would save more lives than they kill. There have been case reports of properly restrained children who were killed or seriously injured by airbag deployments. Whether or not airbags offer a net lifesaving benefit to children who are restrained properly is not known. The consensus of safety experts is that children under age 12 should ride in the rear seat with restraints fastened, especially in cars with passenger-side air bags.

References

National Highway Traffic Safety Administration, Fatality Reduction by Air Bags: Analyses of Accident Data through Early 1996, NHTSA Technical Report, Washington, D.C., August 1996 (DOT HS 808 470), pp. 44-49.

National Highway Traffic Safety Administration, Effectiveness of Occupant Protection Systems and Their Use, Third Report to Congress, Washington, D.C., December 1996, Section III.

SA Ferguson, ER Braver, MA Greene, AK Lund, "Preliminary Report: Initial Estimates of Reductions in Deaths in Frontal Crashes Among Right Front Passengers in Vehicles Equipped with Passenger Airbags," Insurance Institute for Highway Safety, Arlington, VA, September 1996.

3. True or False: If a driver wears their seatbelt properly, the chance of being injured by an inflating airbag is minimal.

Response	Males	Females	Total
True	369 (79.9%)	351 (75.7%)	720 (77.8%)
False	75 (16.1%)	78 (16.9%)	153 (16.5%)
DK	19 (4.0%)	34 (7.4%)	52 (5.6%)

TECHNICAL COMMENT

According to the available literature, this statement is false. A significant number of injuries to the hands, wrists, arms, and faces of belted drivers are being reported. Although most of these injuries are minor, the frequency of moderate and serious arm injuries from airbag deployment has been larger than what safety experts expected before airbags penetrated the vehicle marketplace. The risk of moderate or serious arm injury from airbags may actually be larger for belted occupants than unbelted occupants.

References

National Highway Traffic Safety Administration, Effectiveness of Occupant Protection Systems and Their Use, Third Report to Congress, Washington, D.C., December 1996.

DJ Dalmotas, A German, BE Hendrick, RM Hurley, "Airbag Deployments: The Canadian Experience," Journal of Trauma: Injury, Infection, and Critical Care. 38; 476–481. 1995.

DF Huelke, JL Moore, TW Compton, J Samuels, RS Levine, "Upper Extremity Injuries Related to Airbag Deployments," Journal of Trauma: Injury, Infection, and Critical Care. 38; 482–488. 1995.

SA Ferguson, "Update on Airbag Performance in the United States: Benefits and Problems," Insurance Institute for Highway Safety, Arlington, VA, Paper Presented to Airbag 2,000 Conference, Karlsruhe, Germany, November 1996.

4. True or False: Airbags cause at least as many injuries to drivers as they prevent.

Response	Males	Females	Total
True	107 (23.2%)	141 (30.5%)	248 (26.8%)
False	326 (70.6%)	296 (64.0%)	622 (67.3%)
DK	29 (6.2%)	26 (5.6%)	55 (5.9%)

TECHNICAL COMMENT

This is a difficult question to answer definitively because injuries vary enormously in their degree of severity. The most frequent injuries in crashes are minor. Airbags probably do cause at least as many minor injuries (abrasions and contusions) as they prevent, since the best available estimates are that 20 to 40% of air bag deployments result in at least one deployment-induced injury. For injuries of moderate or greater severity, airbags are reducing significantly the number of injuries to the heads and faces of belted and unbelted drivers, while increasing the number of upper-extremity injuries. Among unbelted drivers, airbags can cause a significant number of moderate and serious chest injuries as well. For serious injuries alone, existing analyses of the National Accident Sampling System have not reached definitive conclusions, but it appears that airbags are reducing serious head injuries to a greater degree than they are increasing serious injuries at other body regions. More study of the injury issue is needed.

References

SA Ferguson, "Update on Airbag Performance in the United States: Benefits and Problems," Insurance Institute for Highway Safety, Arlington, VA, Paper Presented to Airbag 2,000 Conference, Karlsruhe, Germany, November 1996.

AC Malliaris, JH DeBlois, KH Digges, "Air Bag Field Performance and Injury Patterns," SAE Technical Paper 960659, Warrendale, PA.

National Highway Traffic Safety Administration, Effectiveness of Occupant Protection Systems and Their Use, Third Report to Congress, Washington, D.C., December 1996.

5. True or False: A majority of the lives that have been saved by airbags have been among people who were not wearing seatbelts.

Response	Males	Females	Total
True	194 (42.0%)	164 (35.4%)	358 (38.7%)
False	225 (48.6%)	250 (54.0%)	475 (51.3%)
DK	44 (9.4%)	49 (10.5%)	92 (10.0%)

TECHNICAL COMMENT

Although airbags are less effective in preventing fatalities among unbelted occupants than originally thought, a majority (59%) of the lives that have been saved have been among unbelted motorists. This calculation depends on the relative number of belted and unbelted motorists involved in crashes risk (roughly 1 to 1 in serious crashes throughout the United States) and the estimated effectiveness rate for unbelted and belted occupants (13% and 9%, respectively).

References

National Highway Traffic Safety Administration, Fatality Reduction by Air Bags: Analyses of Accident Data Through Early 1996, NHTSA Technical Report, DOT HS 808 470, Washington, D.C., August 1996.

National Highway Traffic Safety Administration, Effectiveness of Occupant Protection Systems and Their Use, Third Report to Congress, Washington, D.C., December 1996.

6. Suppose a car with airbags is crashed into a cement wall. How fast must the car be traveling at impact in order to inflate the airbag? Please answer in miles per hour.

Response	**Males**	**Females**	**Total**
5 MPH or less	80 (17.3%)	33 (7.2%)	114 (12.3%)
6 to 15 MPH	162 (35.2%)	79 (17.0%)	241 (26.1%)
16 to 20 MPH	60 (12.9%)	43 (9.3%)	103 (11.1%)
21 to 30 MPH	64 (13.8%)	119 (25.6%)	168 (18.2%)
31 MPH or more	61 (13.2%)	117 (25.4%)	179 (19.4%)
DK	34 (7.4%)	71 (15.3%)	105 (11.4%)

TECHNICAL COMMENT

U.S. manufacturers have set the deployment threshold around 12 mph, with a "guarantee no fire" value of 9 mph and a "must fire" value of 15 mph, with considerable variability among manufacturers and in the performance of sensors. Serious technical questions have been raised, based on recent field experience, about whether the deployment threshold for air bags should be adjusted upward. A higher threshold would reduce the number of deployments, the replacement costs, and the number of airbag-induced injuries. Setting the threshold higher would, however, cause some people to experience crash-related injuries that might have been prevented by the deployment of an airbag. The technical case for a higher deployment threshold is particularly strong for drivers and passengers who regularly wear safety belts.

References

JV Werner, WW Sorenson, "Survey of Airbag Involved Accidents: An Analysis of Collision Characteristics, System Effectiveness, and Injuries," SAE Technical Paper Series 940802.

DJ Dalmotas, A German, BE Hendrick, RM Hurley, "Airbag Deployments: The Canadian Experience," Journal of Trauma: Injury, Infection, and Critical Care. 38; 476–481. 1995.

JV Werner, SF Roberson, SA Ferguson, KH Digges, "Air Bag Deployment Frequency and Injury Risks," SAE Technical Paper Series 960664.

DJ Dalmotas, RM Hurley, A German, "Air Bag Deployments Involving Restrained Occupants," SAE Technical Paper Series 950868.

SA Ferguson, "Update on Airbag Performance in the United States: Benefits and Problems," Insurance Institute for Highway Safety, Paper Presented to Airbag 2,000 Conference, Karlsruhe, Germany, November 1996.

7. When you drive a vehicle, how many inches of space would you guess there are between the center of the steering wheel and the bridge of your nose?

Response (inches)	Males	Females
12 inches or less	72 (15.5%)	149 (32.2%)
13 - 18 inches	147 (31.8%)	143 (31.0%)
19 - 24 inches	156 (33.7%)	94 (20.3%)
More than 25 inches	72 (15.6%)	26 (5.7%)
DK	15 (3.4%)	50 (10.7%)

TECHNICAL COMMENT

Some clinicians have recommended that drivers allow at least 12 inches of space between their nose and the airbag housing. The best available evidence suggests that women perceive that they drive closer to the steering wheel than they actually do. When a large sample of women drivers were videotaped during normal driving situations, less than one percent had fewer than 12 inches of space between their nose the center of the steering wheel. Yet one third of women in the survey guessed that the bridge of their nose was within 12 inches of the steering wheel. To verify this perception, both the survey results and the observational results need to be replicated.

Reference

E Cullen, KM Stabler, GM Nackay, S Parkin, "How People Sit in Cars: Implications for Driver and Passenger Safety in Frontal Collisions -- The Case of Smart Restraints," 40th Annual Proceedings of the Association for the Advancement of Automotive Medicine, Vancouver, British Columbia, October 7-9, 1996.

SECTION 3: ATTITUDES ABOUT AIR BAGS AND PASSENGER SAFETY

1. Would you favor or oppose a law in your state that would require all children under the age of 10 to be seated in the back seat and buckled?

Responses	All Respondents	Respondents With Kids
Favor strongly	476 (51.5%)	171 (46.4%)
Favor mildly	179 (19.4%)	86 (23.4%)
Oppose mildly	125 (13.5%)	47 (12.6%)
Oppose strongly	120 (13.0%)	57 (15.5%)
DK	25 (2.6%)	8 (2.1%)

TECHNICAL COMMENT

Since the mid-1970s, Germany and France have had laws that require younger children (under age 12 in Germany and 10 in France) to be seated in the rear seat (if a vehicle has a rear seat). This practice has become customary in these countries. The percentages of German and French children observed riding in the front seat are typically less than 10%. In the United States, anywhere between 30 and 50% of children under the age of 12 are observed riding in the front seat. Several states (New York, California, and Massachusetts) are at the beginning stages of public deliberation about whether state legislation should be passed to require children to sit in the rear seat.

2. Do you favor or oppose the current law requiring all new vehicles to be equipped with dual-front airbags?

Responses	**Males**	**Females**	**All Respondents**
Strongly favor	203 (43.9%)	166 (35.8%)	369 (39.8%)
Mildly favor	117 (25.3%)	127 (27.5%)	244 (26.4%)
Mildly oppose	62 (13.4%)	74 (15.9%)	135 (14.6%)
Strongly oppose	67 (14.5%)	69 (15.0%)	136 (14.7%)
DK	14 (2.9%)	27 (5.8%)	40 (4.4%)

TECHNICAL COMMENT

This strong level of public support for mandatory air bags is no less than the level of public support measured in the mid-1980s and early 1990s. The stronger level of support of men compared to women is not typical of a public health and safety issue, possibly reflecting concerns of women about the airbag technology.

Reference

J Flynn, P Slovic, and CK Mertz, "Gender, Race, and Perception of Environmental Health Risks," Risk Analysis. 14(6), 1101-1108 (1994).

3. Compared to three years ago, would you say your attitude toward airbags is more favorable now, less favorable now, or about the same as it was three years ago?

Responses	**Males**	**Females**	**All Respondents**
Less Favorable Now	95 (20.5%)	146 (31.5%)	240 (26.0%)
More Favorable Now	96 (20.7%)	79 (17.0%)	174 (18.8%)
About the Same	270 (58.4%)	230 (49.6%)	500 (54.0%)
DK	2 (0.4%)	9 (1.9%)	11 (1.1%)

TECHNICAL COMMENT

Given the massive negative publicity about the dangers of airbags, it is perhaps surprising that supportive public attitudes have been maintained. Clear indications of erosion in women's support for airbags are evident.

4. Suppose your next vehicle is equipped with airbags but the government allowed dealers to disconnect the airbags at the buyer's request. Would you be likely to request that your airbags be disconnected?

Response	Males	Females	All Respondents
Yes	108 (23.4%)	160 (34.6%)	268 (29.0%)
No	342 (74.0%)	289 (62.4%)	631 (68.2%)
DK	12 (2.6%)	14 (3.1%)	26 (2.8%)

TECHNICAL COMMENT

The government currently allows disconnection only for documented medical reasons. NHTSA is now reconsidering this policy, though there is substantial opposition to a "disconnect on demand" policy.

5. Suppose your next vehicle is equipped with airbags that can be turned on or off by the driver at the start of the trip. Can you imagine any trips when you might choose to turn your airbag system off?

Responses	**Males**	**Females**	**All Respondents**
Yes	141 (30.5%)	165 (35.6%)	305 (33.0%)
No	315 (68.0%)	288 (62.3%)	603 (65.2%)
DK	6 (1.5%)	9 (2.1%)	17 (1.8%)

Most common examples cited in support of "yes" response are: child/baby in front seat (30.5%), leave off all the time (16.7%), short trip (15.4%), short people (12.2%).

TECHNICAL COMMENT

Manual cutoff switches are already permitted on vehicles that do not have a rear seat (e.g., pickup trucks).

6. On the next vehicle you buy, would you be willing to pay $150 extra for a special airbag that would not deploy in a crash if someone was located too close to the airbag?

Response	**Males**	**Females**	**All Respondents**
Yes	225 (48.6%)	268 (57.9%)	493 (53.3%)
No	219 (47.4%)	167 (36.1%)	386 (41.8%)
DK	18 (3.9%)	28 (6.0%)	46 (5.0%)

TECHNICAL COMMENT

There are various technical approaches to designing a system that would suppress or slow airbag deployment when children are in the deployment zone. These systems use proximity sensors. Their reliability is now under serious examination. The incremental cost of most of the suppression systems under discussion are much lower than the $150 per vehicle cited in this question.

CONCLUSION

The survey results suggest that there is widespread public support for airbags in the United States. However, this support is contingent to some extent on a variety of misperceptions about the technology. More public education about the risks and benefits is clearly needed. There is also substantial public support for policies to reduce the dangers of airbags, such as requiring children under the age of 10 to sit in the rear seat and wear safety belts and designing improved airbag systems.

SAFER IN THE BACK, AND BUCKLE UP!

PROSPECTUS FOR A CONTROLLED COMMUNITY-BASED TRIAL

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PROJECT SUMMARY

This prospectus calls for the design, implementation, and evaluation of ten community-based intervention projects around the country aimed at changing the seating locations and restraint-use patterns of children in passenger cars and light trucks. The growing prevalence of passenger-side air bags, which pose a real danger to children in the front seat (especially unrestrained or improperly restrained children) has highlighted the safety advantages of rear-seat occupancy. The goal of the campaign is to induce all children under the age of 12 to be seated in the rear seat (if one exists) and to be properly restrained in a safety belt or child restraint device. If successful, such projects could pave the way toward a new national norm about child safety in America.

The projects will be executed in an experimental design, with matched treatment and control communities. Rigorous evaluation based on roadside observation of child behaviors and surveys of attitudes/knowledge of parents and children will be conducted in each community. The primary message of each campaign would be proper seating position ("KIDS IN THE BACK"), with a related plug for proper restraint ("BUCKLE UP"). The ten community-based campaigns are intended to complement -- and act synergistically with -- the national education campaigns that have been launched since Delores Ambrose, a properly belted 5-year old girl, was fatally injured by an inflating airbag in Nashville, Tennessee in the fall of 1995.

Funding for the project is being sought from the Centers for Disease Control, and the National Highway Safety Administration, agencies with experience supervising community-based projects. It is estimated that each community-based campaign (including evaluation) would cost $250,000 over a two-year period, for a total cost of $2.5 million. The program will be led by scientists at the Harvard School of Public Health and the Education Development Center in Newton, Massachusetts, with designated leaders from each of the ten participating communities responsible for community-based activities. An advisory committee of scientists from NHTSA, CDC, and the private sector will help guide the project.

Statement of the Problem

During the 1985-1996 period, 15,000 American children under the age of 12 were killed when traveling as an occupant of a motor vehicle. Another 75,000 children suffered serious nonfatal injuries. About one-third of these deaths and injuries -- 5,000 and 25,000, respectively -- struck children who were seated in the front seat of a passenger car or light truck. The best estimates are that 30% of these children (1,500) would be alive today had they been seated in the back seat instead of the front seat at the time of the crash. The number of seriously injured children would have been reduced by a comparable percentage.

If aggressive steps are not taken, the number of children killed and injured in the front seat may actually increase in the next ten years. The widespread introduction of passenger-side air bags into passenger cars and light trucks is exposing young children to larger risks of death and injury in crashes than would have occurred had passenger-side airbags not been introduced. Although future airbag designs may be more protective of children, there are already 30 million vehicles on the road with passenger-side airbags and another 30 million vehicles in the production pipeline that are unlikely to be completely safe for children. The United States is unlikely to turn against passenger-side airbags because the best available evidence, while limited, suggests that the lives of significant numbers of adult passengers are being saved by passenger-side airbags. The danger posed by airbags presents an opportunity for America to do what it probably should have done decades ago: develop norms concerning the proper seating position of children in motor vehicles.

Behavioral Solutions are Feasible

It is eminently feasible to change parental and child behaviors regarding motor vehicle safety. In 1978, only 20% of infants and toddlers in the United States were observed traveling in a child restraint device. Today, that number exceeds 80%.

Child seating position behaviors also can be changed. In France and Germany, younger children generally sit in the rear seat. Observational surveys undertaken by the Harvard Center for Risk Analysis have shown that fewer than 10% of German and French children under the age of 12 sit in the front seat. In contrast, the best available estimates are that three times as many American children of the same ages (30+%) are observed riding in the front seats of motor vehicles.

The child seating patterns of American children vary substantially throughout the country. The national Fatal Accident Reporting System records the seating position of every child (dead or alive) in the United States who is in a vehicle when a fatal crash occurs. During the past decade, the percentage of children (age 12 and under) located in the front seat during these crashes varied by state, from a high of 40% in the state of Mississippi to a low of 20% in Rhode Island. Among infants, the state-by-state variation is larger: from a high of 56% in Mississippi and North Dakota to a low of 9% in Massachusetts. For toddlers the range is from 42% in Kentucky to 10% in Rhode Island. For 5-8 year olds the range is from 40% in Maine to 14% in Hawaii. For the older children, aged 9-12, the range is from 57% in Vermont to 18% in Rhode Island. This substantial variation in child seating behaviors suggests that, through changes in social norms, the seating positions of children can be changed.

THE CONTROLLED, COMMUNITY-BASED INTERVENTION TRIAL

A central tool in the science of public health protection is the controlled, community-based intervention trial. In an ideal situation, communities with similar characteristics are identified and then randomly assigned to "treatment" and "control" communities. More often (in real-world situations), the "treatment" communities are recruited based on a combination of factors, and the "control" communities are selected to match them.

The nature of the intervention depends upon the health problem of focus and current knowledge of available, effective prevention strategies. The "treatment" communities receive the intervention, which may include screening, distribution or installation of devices, enforcement of laws and regulations, or health education programs, while the "control" communities serve as comparisons for evaluating the effectiveness of the intervention. The evaluation consists of baseline and post-campaign measurements selected to reflect the objectives of the intervention. To test for lasting effects, repeat measurements may be taken well after the campaign is concluded. In addition, process and formative evaluations are carried out to describe the steps taken to implement the intervention and document any local characteristics and variations that may serve to hinder or promote the success of implementation.

The classic controlled, community-based intervention trial was the Stanford Heart Disease Prevention Project, which demonstrated in the 1970s that a multi-media approach, in conjunction with face-to-face counseling, was successful in changing dietary and lifestyle factors, thereby reducing risk factors for coronary heart disease. In the field of injury prevention, recent trials have demonstrated success at increasing the rate of both safety belt use and bicycle helmet use.

Some interventions have multiple messages (e.g., the Massachusetts Statewide Childhood Injury Prevention Program and the Massachusetts Saving Lives Program), while others focus on a single message (the Harborview bicycle helmet promotion campaign). There has been only one community-based attempt in the United States to change child seating behaviors. In North Carolina, the Insurance Institute for Highway Safety sought to both increase child restraint use and move children to the rear seat by conducting a campaign at several schools and day care centers. Other schools and day care centers in the same communities served as controls. In this limited campaign, which emphasized restraint use more than seating position, the seating positions of children were not affected significantly (though restraint-use behaviors were). Thus, a major controlled trial with a single uniform message to place children in rear seating-positions is clearly needed.

THE OVERALL GOAL OF A CHILD SEATING-POSITION TRIAL

The basic purpose of a child-seating trial would be to demonstrate that social norms about child seating position (as reflected in increased rate of placement of children in the rear seat) can be accomplished at the community level through known interventions to effect behavioral change, without engendering intense opposition from parents, children, and community leaders. If such evidence is generated in several diverse communities throughout the United States, the groundwork will be improved for a new national norm, such as those now in effect in Germany and France, that younger children to sit in the back seat. In addition, as has been the case with the increasing popularity of bicycle helmet campaigns, the information can be used to develop local health promotion efforts to work in concert with legislative and enforcement efforts. If the trial is not successful, U.S. policymakers should be encouraged to pursue other strategies, perhaps advanced technological ones, aimed at better protection of children who sit in the front seats of motor vehicles.

Some states (California, New York, and Massachusetts) are already at the beginning stages of deliberation about the passage of laws to require children to sit in the rear seat. Rhode Island recently passed such a law. If the historical track record regarding safety belt use laws and child restraint use laws is any guide, it will take at least a decade for these laws to be passed and enforced in a majority of states around the country. Indeed, evidence from the trial proposed here could play an important role in accelerating the interest of legislators in passing seating-position laws.

TRIALS AS PART OF A LARGER NATIONAL CAMPAIGN

There is already a national campaign aimed at moving kids from the front seat to the back seat. It began in the fall of 1995, when a 5-year old girl in Nashville, Tennessee (Delores Ambrose) was fatally injured by a passenger-side airbag. By all accounts, this girl was probably belted when the crash occurred. Both the federal government and the private sector (car manufacturers, insurers, and airbag suppliers) are participating in this multi-million dollar campaign. The national campaign emphasizes safety belt and child restraint use, but it also highlights the rear seat as the safest place for children.

Although the community-based interventions proposed here would occur in the context of the national campaign, to which both the control and treatment communities would be exposed, our proposed project differs from the national campaigns in three respects. First, the proposed community program will focus on a single, uniform message ("Safer in the back"). Second, it will have several components to reinforce this message in multiple settings and institutions at the community level. Third, it would rely on a well-organized, grass-roots campaign with a substantial level of local involvement that can rarely be engendered by national campaigns. Thus, the national efforts and the trial proposed here would be complementary: the readiness of the communities to accept the message delivered by the proposed project will be enhanced by the existing national media campaign.

THE TRIAL

The development of the intervention will be guided by concepts derived from various social sciences: the Theory of Planned Behavior and the Health Belief Model. Such concepts are now being commonly applied in the design and implementation of public health efforts that aim to alter health-related behaviors. The process will also incorporate community-organizing principles with local groups involved in the steps taken to define the problem, set up goals, develop strategies, and implement the program.

Design: Ten diverse communities in the United States will be selected to receive the intervention. Site selection criteria will include size (number of residents, children, and new vehicles), location (rural, urban, suburban), historical rates of children riding in front seat (based on FARS data and the older 19 cities study), the historical rate of injuries to children, the proportion of ethnic minorities, median household income, and the presence of a local health department/health officer. Each intervention community will be matched with two control communities for the evaluation. The controls will not be located in close geographic proximity to the intervention sites.

The Intervention: There will be two components to the intervention. The first component is the establishment of a community coalition to provide direction and broad penetration of the campaign. The coalition will be developed by a local coordinator paid for services by the national project who is affiliated with a local agency (such as health department, police, or Mayor's office). The coalition will identify the most promising local channels for disseminating information and stimulating collaborative efforts with public and private organization to support the project and carry out the intervention.

The second component of the intervention is an extensive health education program to increase placement of children in the back seat of motor vehicles. The health-education program will be devised to address the spectrum of prevention, relying on a six-tier approach: Strengthening individual knowledge and skills; promoting community education; educating providers; fostering coalitions; changing organizational practices; and influencing policy and legislation. The program will include a media campaign of informational messages and special features carried by local media (newspapers, local radio and cable tv) that will be reinforced by projects and activities in a variety of settings (schools, day care centers, youth serving organizations, businesses, soccer and baseball leagues, physician offices, local police and fire departments).

The development and implementation of the health education program will be led by the Education Development Center (EDC) in collaboration with behavioral scientists and maternal and child health specialists at the Harvard School of Public Health. EDC has extensive experience in numerous health promotion and education programs aimed at children, parents, and professionals. These programs range in topics from teen worker safety, drug abuse, and violence prevention to safety belt and child restraint use.

Evaluation: The primary outcome measure used to evaluate the intervention will be the proportion of children riding in the front seat. A 10 percentage point reduction in the rate at which children ride in the front seat (say, a decline from 30 to 20%) would certainly be a successful accomplishment, though the longrun target should be to reduce the rate below 10%, as has been achieved in Germany and France. This change would be above and beyond what is achieved in the control communities through the national education campaign. Rates of child seating positions will be determined through observations at pre-selected, representative random sites in each of the 30 communities (10 treatment, 20 control). Baseline observations will be conducted in both control and treatment communities in the fall of 1998, prior to launching the intervention during calendar year 1999. Interim measurements will be taken in mid-2000. The final measurements will be taken six months after the trial ends, in the late fall of 2001. This outcome evaluation will be supplemented by surveys of community households with children to elicit self-reported practices, knowledge, and attitudes about child sitting positions, to be administered through telephone interviews pre- and post intervention. These telephone surveys will also solicit information about exposure to the interventions in order to determine the rate of penetration of the message in each of the participating communities.

A detailed process evaluation will be carried out at each of the intervention sites. Tools for the process evaluation will be developed centrally and completed by the coordinator at each site. The process evaluation will include records of the intervention activities, such as the number of media events that took place, quantities of materials distributed, number of coalition meetings convened, and joint activities carried out by community organizations. Extensive formative evaluation will be done prior to the initiation of the intervention in order to design materials, identify barriers and facilitating factors, and fine tune the manner of implementation to the target population in each locale.

MANAGEMENT OF THE TRIAL

The trial will be designed, managed, and evaluated as a collaborative effort between Harvard and EDC with Graham and Gallagher as co-principal investigators. Professor John D. Graham, Ph.D. of the Harvard School of Public Health is a national authority in the field of auto safety research with special expertise in the field of occupant crash protection. Ms. Susan Gallagher of the Education Development Center directed the pioneering community-based injury prevention program known as SCIPP during 1979-1982, and has extensive experience in evaluation of community programs.

SCHEDULE FOR THE TRIAL

This three-year project will be conducted in several phases as follows:

Phase 1. Baseline: The plan is to launch the project in the fall of 1997, starting with site selection, reaching agreements with the intervention communities, conducting baseline observations of seating positions, and household telephone surveys, and hiring of community coordinators.

Phase 2. Planning: The community coalitions will be convened January 1, 1998 and operate for the duration of the project. During this phase, focus groups will be conducted and the appropriate materials developed.

Phase 3. Implementation: The intervention will be implemented and followed by planned evaluation measures, including process evaluation, observations of sitting positions during the intervention and at its conclusion, and a repeat telephone survey at the end of this implementation phase.

Phase 4. Assessment: The final observation is scheduled to take place six month following the end of the intervention. Data analysis and final report will be completed during this phase.

BUDGET

The budget for the trial is $250,000 per community, or a total of $2.5 million for the three years. About 10% of this amount will be awarded to EDC and Harvard. The cost for each community includes a full time project director, three part-time community coordinators, partial compensation for the Co-PIs, random dial digit telephone surveys at pre- and post intervention, focus groups, vehicle observation studies in 30 communities at four different points of time, material development, travel (primarily to the chosen communities), and data analysis costs.

Funding is being sought from the Centers for Disease Control and the National Highway Traffic Safety Administration. An advisory committee of scientists from CDC, NHTSA, and the private sector will help guide the project.

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The Cost-effectiveness of Air Bags by Seating Position

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Context.—Motor vehicle crashes continue to cause significant mortality and morbidity in the United States. Installation of air bags in new passenger vehicles is a major initiative in the field of injury prevention.

Objective.—To assess the net health consequences and cost-effectiveness of driver's side and front passenger air bags from a societal perspective, taking into account the increased risk to children who occupy the front passenger seat and the diminished effectiveness for older adults.

Design.—A deterministic state transition model tracked a hypothetical cohort of new vehicles over a 20-year period for 3 strategies: (1) installation of safety belts, (2) installation of driver's side air bags in addition to safety belts, and (3) installation of front passenger air bags in addition to safety belts and driver's side air bags. Changes in health outcomes, valued in terms of quality-adjusted life-years (QALYs) and costs (in 1993 dollars), were projected following the recommendations of the Panel on Cost-effectiveness in Health and Medicine.

Participants.—US population-based and convenience sample data were used.

Main Outcome Measure.—Incremental cost-effectiveness ratios.

Results.—Safety belts are cost saving, even at 50% use. The addition of driver's side air bags to safety belts results in net health benefits at an incremental cost of $24 000 per QALY saved. The further addition of front passenger air bags results in an incremental net benefit at a higher incremental cost of $61 000 per QALY saved. Results were sensitive to the unit cost of air bag systems, their effectiveness, baseline fatality rates, the ratio of injuries to fatalities, and the real discount rate.

Conclusions.—Both air bag systems save life-years at costs that are comparable to many medical and public health practices. Immediate steps can be taken to enhance the cost-effectiveness of front passenger air bags, such as moving children to the rear seat.

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MOTOR VEHICLE crashes are a significant cause of mortality and morbidity in the United States. They are the leading cause of death among children and young adults and a major cause of brain and spinal cord injury.[1,2] In 1994, 20 647 drivers and 6491 front passengers suffered fatal injuries in crashes involving the 180 million passenger cars and light trucks registered in the United States.[3,4] In addition, nearly 1.5 million vehicle occupants experienced nonfatal injuries, of which 7% were severe enough to cause some degree of residual functional limitation 1 year after the crash.[5]

One of the recent responses to the crash-injury problem has been the installation of air bag systems in new motor vehicles. More than 56 million new vehicles were sold in the United States with a driver's side air bag system during model years 1989 through 1996; 27 million of these vehicles were also equipped with a front passenger air bag.[6] Dual air bags (ie, driver's side and front passenger) became required standard equipment in all new passenger cars sold in the United States beginning in 1997; all light trucks are required to have them beginning in 1998.[6] Although market penetration of air bags has been most rapid in the United States, air bags are also penetrating new vehicle markets in Europe and Asia without regulatory impetus.

An air bag system is composed of 3 components: an air bag module that houses the inflator and bag, crash sensors that measure deceleration and trigger deployment, and an electronic diagnostic unit that monitors the operation of the system. Current air bag systems are designed to inflate in frontal or front angle crashes, which account for approximately 65% of fatalities to front seat vehicle occupants.[4] The air bags deploy within about 0.05 second after the sensors detect a rate of deceleration equivalent to striking a brick wall at 10 to 15 mph. The deployed air bags begin to deflate 0.2 second following impact; once deployed, they must be replaced.

See also p 1437.

In the early 1980s, several economic evaluations reached conflicting conclusions about whether the additional effectiveness offered by air bags relative to safety belts would justify the costs of air bags.[7,8] The benefit and cost estimates in these early studies were based primarily on expert judgment and experimental testing because few real-world data on air bags were available. Since 1989, the database on air bag performance has expanded rapidly. It has been estimated that approximately 782 000 air bag deployments occurred in the United States from 1989 to 1995[9] at a deployment rate of approximately 4 inflations per 1000 vehicle-years.[10]

Capitalizing on the availability of real-world data, recent studies have evaluated the effectiveness of the air bag systems installed in US vehicles.[6,9,11-15] These studies show that air bag deployments reduce fatal injuries to front seat occupants in frontal crashes. The National Highway Traffic Safety Administration (NHTSA) estimated that between 1989 and February 15, 1997, driver's side and front passenger air bags saved 1639 and 189 lives, respectively.[16]

Some evidence suggests that air bags cause injuries. Air bags must deploy within milliseconds of the beginning of a crash and at very high speeds to protect occupants. The energy produced by the rapidly deploying air bag has the potential to injure someone whose hands, arms, chest, head, or face are in the path of the air bag while it deploys. Although most air bag–induced injuries have been minor, serious ones increasingly are reported. Twenty-one driver fatalities and 2 adult front passenger fatalities, mostly

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among elderly, short women, have occurred because of air bag deployments in various crash situations.[16] Most disturbing is the mounting evidence from in-depth crash investigations that children in the front passenger seat are encountering unique hazards in their interactions with air bags.[17-19] Front passenger air bags have been responsible for 38 child fatalities in crash situations that would not likely have been fatal in the absence of the air bag deployment.[16,18]

The objective of our study is to evaluate the costs, benefits, and cost-effectiveness of US air bag systems compared with manual safety belt systems. We specifically evaluate the incremental benefits, risks, and costs of the addition of driver's side air bags to the familiar manual safety belt systems and of front passenger air bags to driver's side air bags. We also compare the cost-effectiveness ratios for air bags with ratios for a variety of common medical and public health interventions. We emphasize how the cost-effectiveness ratios for air bags might change if federal agencies, state governments, manufacturers, or citizens implement various behavioral policies or technological innovations currently under consideration.

METHODS

Cost-effectiveness Analysis

The method of cost-effectiveness analysis used here, particularly our reference case analysis, is consistent with the consensus recommendations of the Panel on Cost-effectiveness in Health and Medicine commissioned by the US Department of Health and Human Services.[20,21] Intended to inform resource allocation decisions at the societal level, the analysis adopts the societal perspective and incorporates information on all risks, costs, and benefits resulting from these strategies, regardless of who incurs them. The reference case is defined by a standard set of methods and assumptions and serves to facilitate valid comparison of cost-effectiveness ratios across studies of diverse public health and clinical interventions.

A cost-effectiveness analysis evaluates a given health intervention through the use of a cost-effectiveness ratio. In this ratio, all changes in resource use (relative to a stated alternative and valued in monetary terms) are captured in the numerator, and all health effects of an intervention (relative to the alternative) are captured in the denominator. Thus, the productivity costs of morbidity and functional limitation are incorporated into the denominator.[20] The reference case incorporates both mortality and morbidity consequences in the denominator using the single measure of quality-adjusted life-years (QALYs).

A deterministic state transition model using an Excel spreadsheet[22] was devised to track a hypothetical fleet of 10 million new vehicles for a period of 20 years. The number of vehicles in the fleet decreases as they are scrapped because of normal use and accident-related damage. The overall normal vehicle scrappage rates were assumed to be 15% at year 5, 50% at year 10, 65% at year 15, and 100% at year 20 (the maximum vehicle life is assumed to be 20 years).[23] The number of air bag deployments in a year is estimated by multiplying the number of vehicles in the fleet for that year by the deployment rate (ie, deployments per vehicle-year). If the cost of replacement approaches the residual value of the damaged vehicle, then the deployed air bags are not replaced and the vehicle is assumed to be scrapped. Based on limited experience, the replacement rates for air bags are 70% during year 1, 59% during year 2, 56% during year 3, 40% during year 4, 21% during year 5, 10% during years 6 through 10, and 0% during years 11 through 20.[10]

Based on the profile of vehicles in the fleet over its lifetime, we project changes in resource costs and health outcomes for 3 strategies: (1) installation of manual lap and shoulder belt systems as the status quo, (2) installation of driver's side air bags in addition to safety belts, and (3) installation of front passenger air bags in addition to safety belts and driver's side air bags. The results are presented as incremental cost-effectiveness ratios with health effects expressed in QALYs and costs expressed in 1993 US dollars. All future health effects and costs (incurred beyond the initial year of the intervention in the model) were discounted using a 3% annual discount rate, which is intended to reflect a real rate of time preference or a real rate of return on alternative investment opportunities. The cost-effectiveness estimates are independent of the size of the fleet modeled.

The target population of the present study is drivers or front passengers of any age in the United States. The literature suggests differences in the effectiveness of air bags for distinct subgroups in the population (ie, for children younger than 10 years, adults aged between 10 and 64 years, and adults older than 65 years) as reviewed below. We assume that owners will not disarm their air bags and that driver behavior is not affected by the presence of an air bag. The number of fatalities avoided for a subgroup is estimated by multiplying the number of vehicles, the baseline fatality rate, the percentage of the population involved in crashes represented by the subgroup, and the effectiveness of the intervention for reducing fatali for the subgroup. Similarly, the number of nonfatal injur avoided for a subgroup is estimated as the number of baseline fatalities for the subgroup multiplied by the ratio of injuries to fatalities and the effectiveness of the intervention for reducing injuries. The model estimates the installation, replacement, and maintenance costs and the medical and legal resources saved by an intervention as a function of the profile of vehicles in the fleet over its lifetime, the rates of air bag deployment and vehicle scrappage, and the numbers of fatalities and injuries. The model estimates changes in QALYs by combining the estimated numbers of fatalities and injuries avoided with weights that are generated by a Markov submodel using TreeAge[24] based on average health-related[25] and trauma-related[26] quality-of-life data.

To explore and validate the behavior of the model, we performed a global univariate sensitivity analysis that varied each model input by ±30%. Focused sensitivity analyses were then performed on the most uncertain input parameters to determine how much the cost-effectiveness ratios changed in response to plausible changes in their values. Reference case values and ranges for model inputs are listed in Table 1.[2-5,9,10,12,14,23,25-31]

Event Rates for Injuries and Fatalities

Rates of death and injury vary by seating position. In 1994, there were 115 driver fatalities per million vehicles compared with 36 front passenger fatalities per million vehicles.[3,4] The smaller rate of death in the right front seat reflects the lower rate of occupancy in this seating position. Among the fatally injured drivers in 1994, 16.2% were aged 65 years or older. Among the fatally injured front passengers, 5.3% were younger than 10 years, and 21.6% were aged 65 years or older.[4]

Crash-related injuries are typically classified by severity using the Association for the Advancement of Automotive Medicine's 6-point Abbreviated Injury Scale (AIS).[32] According to this scale, levels AIS 1 to AIS 6 correspond to progressively more life-threatening injuries. The most severe injury any individual suffers is normally referred to as the maximum AIS (MAIS). Since air bags have little net effectiveness on MAIS 1 injuries (as discussed below), they are not included in the analysis. In addition, most MAIS 6 injuries are fatal, and we assume they are counted among the fatalities. For each occupant killed in 1994, another 8.7 occupants suffered moderate to critical (MAIS 2-5) nonfatal injuries as defined by the 1990 version of the AIS.[3] Since we use the only injury cost estimates available in the literature and they refer to injuries coded

Table 1.—Reference Case Values and Ranges Used in Sensitivity Analysis

Variables	Baseline Value	Range	References
Event rates			
Fatality rate per million vehicle-years, No.			
Driver	115	80-149†	NHTSA[4]
Front passenger	36	25-47†	
Ratio of MAIS 2-5 injuries to fatalities, %	16.8	11.8-21.8†	NHTSA,[3] Garthe et al[27]
Air bag deployment rate per 1000 vehicle-years	4	2.8-5.2†	Ferguson et al[12]
Percent of MAIS 2-5 by			
MAIS 2	77.6	...	Segui-Gomez,[5] Garthe et al[27]
MAIS 3	18.6		
MAIS 4	3.0		
MAIS 5	0.8		
Target population, %			
Drivers >64 y	16.2	...	NHTSA[4]
Front passengers <10 y	5.3		
Front passengers >65 y	21.6		
Intervention effectiveness rate			
Occupant seat belt use, %	50	...	Evans,[28] NHTSA[29]
Seatbelts, %	45		
Air bags for adults 10-64 y, %	13	5-19	Ferguson,[9] Kahane[14]
Air bags for adults >64 y, %	5	0-19	
Air bags for children <10 y, %	−21	−88-0	
Costs, in 1993 dollars			
Air bag installation			
Driver's side	278	236-319	NHTSA[30]
Dual	410	356-464	
Air bag maintenance			
Driver's side	25	0-50	American Honda Motors Co[31]
Dual	50	0-100	
Air bag replacement‡			
Driver's side	664	240-1800	Werner and Sorenson[10]
Dual	1452	720-5435	
Fatality, total cost	99 992	69 994-129 990†	Blincoe[2]
Injury, lifetime cost			
MAIS 2	13 884	9718-18 049†	Blincoe,[2] Garthe et al[27]
MAIS 3	46 469	32 528-60 410†	
MAIS 4	137 116	95 981-178 251†	
MAIS 5	440 802	308 561-573 043†	
Quality-of-life weights			
Because of injury for			
MAIS 2	0.71	0.50-0.92†	Segui-Gomez,[5] AAMA,[23] MacKenzie et al[26]
MAIS 3	0.67	0.47-0.87†	
MAIS 4	0.51	0.36-0.66†	
MAIS 5	0.06	0.04-0.08†	
For aging of general population§			
<45 y	1.0, 1.0	...	Fryback et al[25]
45-54 y	0.94, 0.90		
55-64 y	0.87, 0.87		
5-74 y	0.84, 0.83		
75-85 y	0.84, 0.79		
>85 y	0.82, 0.80		

*MAIS indicates maximum Abbreviated Injury Scale; NHTSA, the National Highway Traffic Safety Administration; AAAM, the Association for the Advancement of Automotive Medicine; and ellipses, not applicable.
†Range reflects ±30% of base-case value.
‡See "Methods" section in text for the probabilities of air bag replacement as a function of vehicle age and vehicle survival data.
§These are age-specific weights from the time trade-off method for the general population for men and women from the Beaver Dam Health Outcomes Study.

—according to the 1985 version of AIS, we adjusted this ratio of nonfatal injuries to fatalities to 16.8 using a recently suggested method[27] and distributed the cases by MAIS level (77.6% MAIS 2, 18.6% MAIS 3, 3% MAIS 4, and 0.8% MAIS 5).

Event rates of fatalities and injuries per vehicle-year for the reference case are based on the above data and are assumed to be constant from the point of vehicle purchase until the vehicle is scrapped. New cars are driven more than old cars, yet old cars tend to have more high-risk drivers than new cars. The sensitivity analyses relax our assumptions in both directions.

Effectiveness of Lap-Shoulder Belts

Lap-shoulder belt systems reduce the risk of fatality and serious injury (given a collision) by about 45% when used by drivers and front passengers.[14,28] For years voluntary rates of adult safety belt use were less than 20% in the United States[33]; consequently, 49 states adopted some form of mandatory safety belt use law for adults (all but New Hampshire).[6] All 50 states also have laws requiring young children to travel in proper restraint systems.[6] The laws covering the behavior of adults and children are not rigorously enforced by the police in most states, even though it has been demonstrated that restraint use rates depend on the amount and type of police enforcement.[34,35]

National estimates of belt use vary from 30% to 70%.[20] These estimates are known to be biased to unknown degrees by several sources of measurement error. The lower end of the range represents the rate of belt use among fatally injured occupants. The upper end of the range represents use among occupants who survive tow-away crashes and is probably an overestimate because crash survivors may be untruthful to police regarding actual use given current laws. Roadside observational surveys are the most accurate measure of actual behavior but are known to overestimate the belt use rate in crash situations. We assume the operative rate of safety belt use in the United States is 50% in crash situations.[14,30,36] In the sensitivity analysis we consider the implications of 100% belt use.

Effectiveness of Air Bags for Fatalities

Nationwide fatality and injury counts have not yet been influenced significantly by air bags because fewer than 30% of the vehicles on the road in 1995 were equipped with an air bag system. However, national databases with make, model, and type of crash information have been analyzed to assess the real-world performance of air bag systems.[6,9,11-15]

A 1995 study used vehicle registration data to compute overall driver fatality rates per 10 000 registered vehicles for vehicles with air bags and belts and for the same model vehicles with belts only.[11] The study reported driver fatality rates to be 16% lower than expected for vehicles with air bags and manual belts compared with vehicles with belts only.[11] The validity of this estimate depends on the assumptions that crash severities and safety belt use rates are comparable in the 2 fleets of vehicles. While these assumptions are reasonable, they cannot be verified rigorously with information in the Fatal Accident Reporting System (FARS), a national census of fatal motor vehicle crashes maintained by the NHTSA. An update of this study used more data and 2 different methods and reported 2 slightly lower effectiveness estimates of 14% and 15%.[13]

The largest air bag evaluation effort to date was based on FARS data for calendar years 1986 to 1996.[14] This analysis estimated air bag effectiveness in reducing driver fatalities using 2 methods. The first method, which compared the fatality ratios of drivers to passengers in cars with driver-only air bags to ratios associated with similar model cars with no air bags, led to an effectiveness estimate of 10%. The second method, which compared the ratio of fatalities in frontal to nonfrontal crashes for vehicles with air bags to the same ratio for vehicles with no air bags (based on the assumption that air bags are not effective in nonfrontal crashes), led to an effectiveness estimate of 12%. These estimates suggest that the presence of an air bag system reduces the driver's overall fatality risk (in all crashes) by about 11%.[14]

The 11% effectiveness estimate roughly comprises a 13% (95% confidence interval [CI], 6%-19%) reduction in fatality risk among unbelted drivers and a 9% (95% CI, 3%-15%) reduction in fatality risk among belted drivers.[14] Although the difference in effectiveness for unbelted and belted drivers is not statistically significant, the difference is consistent with the results from a similar study of the same data[9] and with expectations derived from biomechanical theory and experimental crash testing.[37]

The effectiveness information for front passenger air bags is more limited than for driver's side air bags because front passenger air bags entered the fleet several years later than driver's side air bags, and there is a much lower rate of occupancy in the front passenger seat.[9] Initial estimates using FARS data for 1992 to 1995 model vehicles suggested 18% fewer passenger deaths overall than expected in frontal crashes of vehicles with dual air bags compared with vehicles with driver-only air bags, or about an 11% effectiveness rate in all crashes.[12] The Kahane[14] analysis indicates that air bags reduce the fatality risk of front seat passengers older than 13 years by about 13%. In its review of the available studies, NHTSA found that the data suggest that driver's side and front passenger air bags appear to be equally effective for occupants aged 13 years and older.[6]

While front passenger air bags appear to decrease fatality risks for adults, evidence suggests that they increase fatality risk for passengers younger than 10 to 15 years.[13,14] The adverse effects of air bags on small children—particularly those who are unrestrained or improperly restrained and slide forward during precrash braking or those who are in rear-facing infant restraint devices—are increasingly documented and often occur in low- to moderate-severity crashes that may not have been fatal (or even injurious) in the absence of air bag deployment.[9,12,14,17,18]

For both driver's side and front passenger air bags we assumed effectiveness rates of 13% for occupants aged 10 to 64 years and 5% for occupants older than 65 years.[9] For front passenger air bags, we assumed an increase of 21% in fatalities and injuries for children younger than 10 years, even though this estimate is based on small counts of childhood fatalities and does not differ significantly from zero.[9] Larger estimates of increased risk to children aged 12 years and younger (28% and 88%) were reported by Kahane[14] using somewhat different data. Sensitivity analyses were performed on these key inputs to the model.

Effectiveness of Air Bags in Preventing Nonfatal Injuries

Air bags are designed to prevent head, face, and upper torso injuries but can also cause upper extremity, chest, and facial injuries. The challenge in air bag effectiveness research is to quantify the changes in magnitude of each type of injury by severity level.

The air bag's effectiveness in reducing serious injuries to the head, face, and upper torso in frontal crashes is statistically significant, has been confirmed in several studies, and is apparent for belted as well as unbelted drivers.[10,14,38] The precise magnitude of the effect is unknown, since estimates from the different studies vary considerably.

Injuries induced by air bag deployment are frequently reported,[10,39,40] with somewhat greater frequency among female drivers.[38] In a study of 2007 air bag deployments in the United States, 42% resulted in at least 1 such injury to a front seat occupant.[9] Of these air bag-induced injuries, 97% were minor (MAIS 1), composed primarily of head contusions and abrasions to the head, neck, face, and upper extremities. An additional 2% were moderate (MAIS 2) and included concussions and rib, sternum, and upper extremity fractures. Among the remaining severe injuries (MAIS 3+), heart lacerations, lung contusions, forearm fractures, and eye injuries were reported. Whether these injured occupants would have suffered more or less severe injuries in the absence of air bag deployments remains unclear.

For baseline values, we assume that air bags cause as many AIS 1 injuries as they prevent, and thus we focus on the more serious injuries (MAIS 2-5), which are expected to have a greater impact on quality-adjusted life expectancy and costs. We also make the assumption that air bags are as effective at reducing MAIS 2 to 5 injuries as they are at reducing fatalities, based on the evidence indicating reduced injuries to the head, face, and chest. However, this assumption will need to be replaced in the future with rigorous estimates derived from detailed studies of the severity distributions of nonfatal injuries in vehicles with and without air bags.

Costs

Like many injury-related preventive health interventions, the major resource investment occurs at the time of the factory installation of the belts and air bags. The factory installation costs for mass-produced manual lap and shoulder belts are assumed to be approximately $57 per

Table 2.—Reference Case Results*

Strategies	Total Net Cost (Includes Savings) per 10 Million Vehicles, in Millions, 1993 Dollars	Total Effectiveness per 10 Million Vehicles, QALYs	Incremental Cost per 10 Million Vehicles, in Millions, 1993 Dollars	Incremental Effectiveness per 10 Million Vehicles, QALYs	Cost-effectiveness Ratio, Incremental Dollars per Incremental QALY
Discounted results (3%)					
No air bags (manual lap-shoulder belts)	−1357†	219629	...	...	...
Driver's side air bag (plus manual restraints)	853	312735	2210	93106	24000
Dual air bag system (plus manual restraints)	2184	3334531	1331	21796	61000
Undiscounted results					
No air bags (manual lap-shoulder belts)	−1853†	479431	...	...	...
Driver's side air bag (plus manual restraints)	210	683821	2063	204390	10000
Dual air bag system (plus manual restraints)	1542	728361	1332	44541	30000
Discounted results (5%)					
No air bags (manual lap-shoulder belts)	−1110†	145234	...	...	...
Driver's side air bag (plus manual restraints)	1172	206471	2282	61237	37000
Dual air bag system (plus manual restraints)	2502	221104	1330	14633	91000

*QALYs indicates quality-adjusted life-years; ellipses, not applicable.
†Net costs are negative because savings exceed belt costs.

vehicle.[30,41] The air bag costs are assumed to be $278 for the driver's side air bag in the steering wheel and for the sensor and control unit and $410 for the dual air bag system.[30] The reported charge for air bag replacement after a crash ranges from $720 to $5435, with a central estimate for high-volume cars around $664 for the driver's side air bag and $1452 for dual air bags.[10] We further assume that air bags require a one-time maintenance check at 10 years (at least for air bags with electronic sensors) that will entail approximately 30 minutes of labor per air bag at a cost of $50 per hour of labor.[31] The costs of air bags (particularly for electronic sensors) may be declining, and thus we performed sensitivity analyses for these estimates.

Resources are consumed as a result of crash-related injuries and fatalities. The present value of lifetime injury-related costs are estimated to be an average of $99 992 per fatality and $27 057 per nonfatal MAIS 2 to 5 injury.[2,42] These figures include insurance administration and legal fees, court costs, and medical costs associated with emergency services, hospitalization, outpatient care, and rehabilitation. These costs are included as savings (ie, negative costs).

Health-Related Quality of Life

A Markov submodel was used to determine the appropriate weights for conversion of the estimated numbers of avoided fatalities and injuries to total QALYs saved for each subgroup of the population. Using data from US life tables and actuarial data on the age distribution of fatalities in motor vehicle crashes,[4] the Markov submodel estimates discounted life expectancy and quality-adjusted life expectancy. Although cost-effectiveness analyses have typically assumed that a life-year saved by an intervention is valued at 1.0 QALY, the Panel on Cost-effectiveness in Health and Medicine recommends, in the reference case, that life-years saved be adjusted to reflect the average health-related quality of life in the target population.[20,21] Lacking specific data on the health status of people in crashes, we used age- and sex-adjusted weights derived from the time trade-off estimates reported in the Beaver Dam Health Outcomes Study (BDHOS).[25] The BDHOS is an ongoing longitudinal cohort study of health status and health-related quality of life for a random sample of adults in a community population. We conservatively assumed that the quality weight for each year of life saved for those younger than 45 years was 1.0, largely because no quality-adjusted data were collected for this younger (and presumably healthier) age range. Discounted QALYs lost per fatality were estimated for an average adult aged between 10 and 65 years (ie, a 37-year-old), an average adult older than 65 years (ie, a 75-year-old), and an average child younger than 10 years (ie, a 5-year-old). We explored the impact of using an alternative health state classification system (ie, the National Center for Health Statistics' *Years of Healthy Life*[43]) in the sensitivity analysis. We also report results without adjusting for baseline population health-related quality of life (ie, assuming QALY weights of 1.0 per life-year).

To account for diminished health-related quality that results from crash-related injuries, we used quality weights associated with each MAIS injury as measured by the Functional Capacity Index (FCI).[26] The FCI weights represent rating scale preferences elicited from a convenience sample for injuries that result in functional limitations persisting longer than 1 year after injury, and they are not age or sex specific. Using data from the National Accident Sampling System's Crashworthiness Data System (NASS CDS) for 1994 and 1995 for those injuries that lead to some functional limitation, average residual quality weights of 0.71, 0.67, 0.51, and 0.06 were assigned to MAIS 2, MAIS 3, MAIS 4, and MAIS 5, respectively.[5,26] Because some MAIS 2 to 5 injuries are transient (ie, within 1 year the health state is restored to normal) and the model considers both persistent and nonpersistent injuries, these residual quality weights were multiplied by the proportions of MAIS 2, MAIS 3, MAIS 4, and MAIS 5 persistent injuries (37.1%, 47.7%, 14.9%, and 85.7%, respectively) and added to the complementary proportions of nonpersistent injuries that were assigned QALY weights of 1.0. This resulted in residual quality weights for all injuries of 0.89 (MAIS 2), 0.84 (MAIS 3), 0.93 (MAIS 4), and 0.19 (MAIS 5).[5] The relatively small percentage of MAIS 4 injuries that result in functional deficits lasting longer than 1 year reduces the relative significance of these injuries.

The final QALY weight for the remaining life expectancy of an injured person was then obtained by multiplying the injury-specific QALY weight to the corresponding age-specific baseline QALY weight for use in the Markov submodel. The QALYs saved by avoiding injuries are then estimated by finding the difference in QALYs between injured individuals and noninjured individuals at the baseline health-related quality of life.

RESULTS

The reference case results are shown in Table 2. Safety belts alone are cost saving, even at a 50% usage rate. The incremental cost-effectiveness of the addition of a driver's side air bag was estimated to be $24 000 per QALY saved. The incremental cost-effectiveness of the addition of the dual air bag system (front passenger plus driver's side air bags) relative to the driver-only air bag was $61 000 per QALY saved. The dual air bag strategy was less attractive because the excess fatality risk for children (ie, negative effectiveness) combined with the lower occupancy rate on the front passenger side resulted in a smaller number of incremental QALYs saved.

Of special interest is the benefit-risk ratio for front passenger air bags, where the lives of about 10 adults are being saved for each child killed using the point estimates in the reference case. As Figure 1 indicates, this ratio is uncertain and changes dramatically as a function of the assumed effectiveness for children. The ratio will need to be reevaluated in the future as vehicles with front passenger air bags are resold to owners with less income and education.

Deterministic single variable sensitivity analyses were performed in which the value of each input variable was varied by ±30% to explore the behavior of the model (Table 3). These results indicated that estimates of cost-effectiveness for various air bag strategies were substantially influenced by the unit cost of the air bag systems, the effectiveness rates for the systems, the baseline fatality rates, the ratio of injuries to fatalities, and the real discount rate. Results were less sensitive to changes in valuations of nonfatal injuries, the cost of treating MAIS 2 to 5 injuries, the maintenance and replacement costs, and the air bag deployment rate.

Considering the full ranges of the uncertain model inputs, the choice of discount rate and the effectiveness rates for the systems have the largest impacts on the model output. As shown in Table 2, applying a discount rate of 5% causes the incremental cost-effectiveness ratio to worsen from \$24 000 to \$37 000 for the driver's side air bag system and from \$61 000 to \$91 000 for the dual air bag system.

As shown in Table 3, decreasing the effectiveness of air bags in reducing mortality and morbidity in adults aged between 10 and 64 years by 30% (from 13% to 9%) increased the cost-effectiveness ratio for the driver's side air bag by 54% to \$37 000 per QALY and for the front passenger air bag by 59% to \$97 000 per QALY. These disproportionate increases occur because the lower effectiveness rate increases the costs (by reducing the medical savings) and decreases the number of QALYs saved. At an effectiveness rate of 17% for adults aged between 10 and 64 years, the cost-effectiveness ratio improves from \$24 000 to \$16 000 per QALY saved for the driver-only air bag and from \$61 000 to \$43 000 per QALY saved for the addition of a dual air bag system. Sensitivity of the cost-effectiveness ratios for both the effectiveness for adults aged between 10 and 64 years and the discount rate is demonstrated in Figure 2.

Efforts to increase adult safety belt use toward 100% could save lives in nonfron-

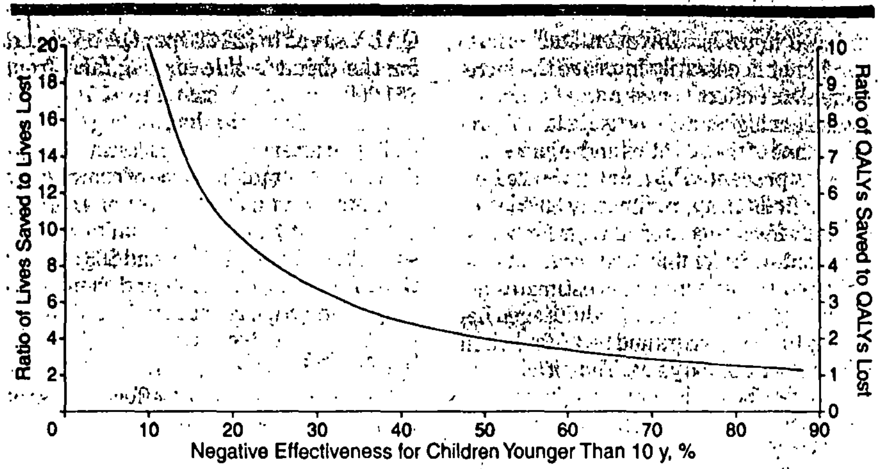

Figure 1.—Risk-benefit ratio for front passenger air bags as a function of the effectiveness for children (undiscounted). QALYs indicates quality-adjusted life-years.

Table 3.—Sensitivity Analysis Results: Changes in Cost-effectiveness Ratios (Dollars in Thousands per QALY)*

Uncertain Variable Changed	Cost-effectiveness Ratio When Values Changed ±30%: Driver	Dual	Cost-effectiveness Ratio for Values Changed Over Plausible Range (If Different): Driver	Dual
Base case	24	61	...	...
Installation costs per car	33-15	79-43	28-19	67-56
Replacement costs	24-24	62-60	25-23	75-60
Maintenance costs	24-23	63-59	25-22	67-55
Cost per MAIS 2-5 and per fatality	21-26	58-64	...	...
Effectiveness for adults 10-64 y	17-37	44-97	...	...
Effectiveness for adults >64 y	23-24	60-62	...	...
Effectiveness for children <10 y	24	65-58	...	...
All effectiveness estimates	16-37	41-110	...	...
Baseline fatality rates	16-37	45-91	...	...
MAIS 2-5 injuries to fatalities ratio	18-33	49-80	...	...
QALY losses	18-34	47-87	...	...

*QALY indicates quality-adjusted life-year; MAIS, maximum Abbreviated Injury Scale; and ellipses, not applicable.

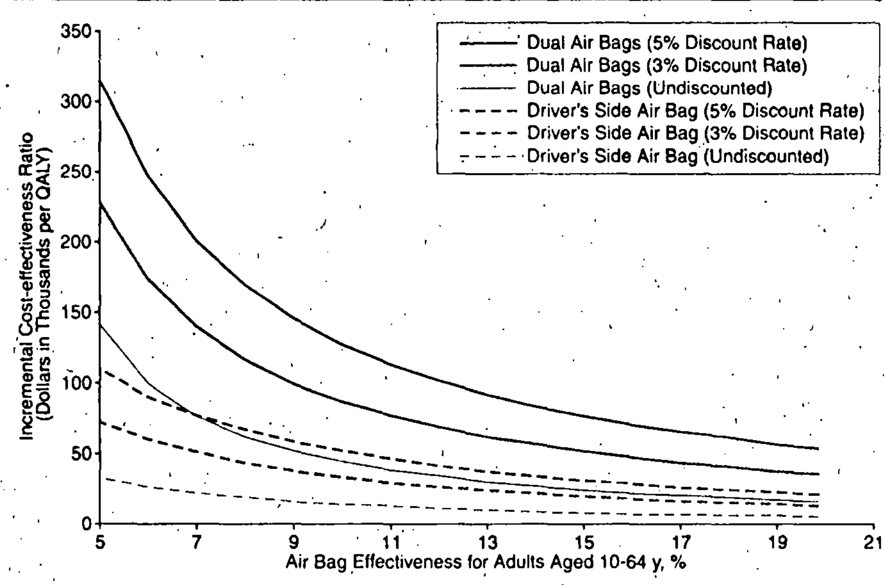

Figure 2.—Sensitivity of incremental cost-effectiveness ratios (\$1000 per quality-adjusted life-year [QALY] for driver's side and front passenger air bags) as a function of air bag effectiveness for adults aged 10 to 64 years and discount rate.

screening for carotid stenosis in asymptomatic persons costs $120 000 per QALY saved (in 1994 US dollars)[47]; and renal dialysis costs $30 000 to $35 000 per year of life saved (in 1990 US dollars).[48] In many preventive interventions, the actual cost-effectiveness ratio is dependent on the risk of the group being targeted and the intensity of the proposed intervention. For instance, the ratio for cervical cancer screening every 4 years has been reported to be $10 000 per QALY; increasing the frequency to every 3 years results in an incremental ratio of $184 500 per QALY; increasing the frequency to every 2 years results in an incremental ratio of $262 800 per QALY.[49] On the other hand, cervical cancer screening for people in the low-income elderly population who have not been screened in recent memory has been reported to be cost saving,[50] in the same way that we showed manual safety belts were cost saving (even at 50% use rates). These examples of cost-effectiveness ratios should be compared with the ratios for air bags with caution because they are not all based on the same assumptions and methods that were recently recommended by the Panel on Cost-effectiveness in Health and Medicine.[20,21,51]

Cost-effectiveness ratios for air bags are comparable to other well-accepted measures in preventive medicine. Immediate steps can be taken to enhance the cost-effectiveness of front passenger air bags, such as moving children to the rear seat and increasing the rate at which children are properly restrained in crashes.

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tal crashes and prevent many air bag–induced injuries. However, such efforts would not necessarily improve the incremental cost-effectiveness ratios for air bags because at higher rates of use belts will prevent some of the fatalities and injuries that are now prevented by air bags. Since Ferguson[9] finds an approximately 30% lower overall effectiveness of air bags for belted occupants than for unbelted occupants, we adjusted the effectiveness estimates accordingly to 9% for belted adults aged between 10 and 64 years and to 3% for belted adults older than 65 years. Thus, if all adults wore safety belts, the cost-effectiveness ratios would change from $24 000 per QALY to $38 000 per QALY saved for the addition of a driver's side air bag to safety belts and from $61 000 per QALY to $102 000 per QALY saved for the additional front passenger air bag.

Several European countries (eg, France and Germany) used to require all children younger than a specified age (10 or 12 years) to be seated in the rear of a motor vehicle (when a rear seat exists). Despite recent amendments to their laws that now allow children to sit in the front if they are properly restrained, it is still customary for children in these countries to ride in the back seat of cars. If similar behavior existed in the United States, then safety benefits would result. In our model when children younger than 10 years are moved to the back seat (with the front seat left empty), the incremental cost-effectiveness ratio for front passenger air bags declines from $61 000 per QALY to $51 000 per QALY, since the danger of air bags to children is eliminated.

If air bags are not effective at reducing MAIS 2 to 5 injuries, then including resources and QALYs saved by avoiding injuries leads to an underestimation of the cost-effectiveness ratios. Considering only the reductions in fatalities associated with air bags, the ratios would be $105 000 per QALY and $235 000 per QALY for driver's side and front passenger air bags, respectively.

The effect of air bags on the safety of adults older than 65 years is uncertain. If air bags are actually as effective for adults older than 65 years as they are for adults between 10 and 65 years, then the ratios drop to $22 000 per QALY saved and $55 000 per QALY saved for driver's side and front passenger air bags, respectively. Alternatively, if the air bags are 0% effective for elderly adults, the ratios increase to $25 000 per QALY saved and $65 000 per QALY saved for driver's side and front passenger air bags, respectively.

If years of life saved are not adjusted for the average health-related quality of life in the population, the cost-effectiveness ratio would fall from $24 000 per QALY saved to $22 000 per QALY saved for the driver's side air bag, and from $61 000 per QALY saved to $55 000 per QALY saved for the dual air bag system. Using an alternative health state classification system as a source of community weights, such as the *Years of Healthy Life*, did not change our qualitative results ($27 000 per QALY and $69 000 per QALY for driver's side and front passenger air bags, respectively).

COMMENT

We compared the cost-effectiveness of adding driver's side air bags to safety belts with that of adding front passenger air bags to the driver-only air bag system. Our analysis revealed that the addition of a driver-only air bag costs $24 000 per QALY saved with current rates of safety belt use. The addition of a front passenger air bag, making a dual front air bag system, costs $61 000 per QALY beyond the savings with a driver-only air bag. To the best of our knowledge, this analysis represents the first cost-effectiveness evaluation of air bags using the real-world effectiveness data that are now available. These figures are applicable only to US air bag systems and do not necessarily apply to the somewhat different air bag designs now available in Australia and parts of Europe, where road conditions and safety belt usage rates are also quite different.[44] There is also some variability in the design of US airbags that may be relevant to cost-effectiveness, but that was not analyzed here.

The estimated benefit-risk ratio for front passenger air bags deserves serious consideration by decision makers. One can question whether it is appropriate to maintain a mandatory policy that causes a net increase in mortality risk to children, even though the lives of 10 adults are being saved for each child that is lost. We are aware of no other mandatory health measure in the United States with a benefit-risk ratio so close to 1.

The net safety benefits and cost-effectiveness of dual air bags would improve considerably if the United States were to adopt policies that encourage or require children to sit in the rear seat. More and proper use of child restraints would also be useful. On the other hand, efforts to increase generally the rate of adult safety belt use, although essential in their own right,[34,35] would reduce the incremental cost-effectiveness of air bags.

The true cost-effectiveness ratio for the front passenger air bag may be worse than our analysis suggests, because effectiveness information is limited. The front passenger air bag is larger, reflecting greater variability in passenger position at the time of deployment, but even this design feature may not be adequate to achieve the effectiveness rates documented for driver's side systems. In addition, US air bag systems were optimized to protect an unbelted 76.5-kg adult male, which may cause effectiveness on the front passenger's side (where a disproportionate share of women and children are located) to be lower than the effectiveness achieved on the driver's side. Further research on the effectiveness of front passenger air bags is needed.

The preference weights for health-related quality of life are subject to change as methodological developments continue. For example, the FCI data were elicited from a convenience sample that included several subgroups of the population and used rating scales whose interval properties are controversial.[45] Ongoing FCI validation efforts will improve the estimates of the proportions of injuries that lead to some persistent functional disability and might change the preference values assigned to those injuries. Since the values for adults were assumed to apply directly to children and the elderly in our analysis, research suggesting differences between subgroups could also change the results.

Since there is no consensus on which particular set of community weights for the general population should be used in studies to inform resource allocation, the quality adjustments for the years of life saved as a result of preventing fatalities could also change. We used time trade-off, community-based preference weights from the BDHOS in the reference case. If years of life saved are not adjusted for the average health-related quality of life in the population, the cost-effectiveness ratio would fall from $24 000 per QALY saved to $22 000 per QALY saved for the driver's side air bag and from $61 000 per QALY saved to $55 000 per QALY saved for the dual system. These smaller ratios for air bags should be used when comparisons are made with other lifesaving interventions that did not adjust for health-related quality of life. We found that using an alternative health state classification system (the *Years of Healthy Life*) did not change our qualitative results ($27 000 per QALY for the driver's side air bag and $69 000 per QALY for the front passenger air bag).

No consensus currently exists about what levels of expenditures are cost-effective, and consequently it is difficult to make absolute statements about whether an intervention is a worthwhile safety investment. We can compare the marginal cost-effectiveness of interventions society has chosen to accept and those that it has not. For example, screening for hypertension costs $12 200 to $42 000 per year of life saved (in 1993 US dollars)[46];

Reductions in Deaths in Frontal Crashes Among Right Front Passengers in Vehicles Equipped With Passenger Air Bags

Elisa R. Braver, PhD; Susan A. Ferguson, PhD; Michael A. Greene, PhD; Adrian K. Lund, PhD

Context.—Virtually all new cars now are equipped with passenger air bags. Determining whether passenger air bags are saving lives is important, particularly because passenger air bags have caused some deaths among children and adults.

Objective.—To assess the effectiveness of passenger air bags in reducing the risk of death in frontal crashes for right front passengers.

Design.—Air bags are designed to protect occupants in frontal crashes. Using Fatality Analysis Reporting System data for calendar years 1992 through 1995, the relative frequency of right front passenger deaths in frontal vs nonfrontal fatal crashes was compared for cars with dual air bags and for cars with driver-only air bags.

Main Outcome Measures.—Odds of right front passengers dying in frontal compared with nonfrontal fatal crashes were computed for 1992 through 1995 model year cars with dual air bags and for cars with driver-only air bags. Percentage reductions in right front passenger deaths in dual air bag vehicles were estimated.

Results.—Right front passenger fatalities were 18% lower than expected in frontal crashes of cars with dual air bags and 11% lower in all crashes. An estimated 73 fewer than expected right front passengers died in 1992 through 1995 model cars with dual air bags during 1992 through 1995. The risk of frontal crash death for right front passengers in cars with dual air bags was reduced 14% among those reported to be using belts and 23% among belt nonusers. Children younger than 10 years in cars with dual air bags had a 34% *increased* risk of dying in frontal crashes.

Conclusions.—Passenger air bags were associated with substantial reductions in fatalities among right front passengers in frontal crashes. However, more children are being killed than are being saved by air bags. Immediate countermeasures to reduce the dangers of air bags to children and adults are suggested.

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THE ON-ROAD EXPERIENCE of cars equipped with driver air bags indicates that air bags are very effective in reducing driver deaths in frontal crashes.[1-4] However, until now there has been insufficient experience to estimate the effectiveness of passenger air bags. Individual crash investigations show these restraints have caused some deaths. As of September 1, 1997, a total of 45 children and infants—33 children aged 1 year through 9 years plus 12 infants—were reported to have been killed by passenger air bag deployments in low-severity crashes that should have been survivable in the absence of the air bags.[5,6] The infants were in rear-facing child seats, which place infants' heads very close to air bag modules so that the force of the deploying air bag can cause serious or fatal head injuries.[5-7] Among the older children, 16 were aged 1 year through 4 years and 17 were aged 5 years through 9 years. Almost all (27 of 33) were unbelted, and 3 (aged 4 years, 7 years, and 9 years) used only their lap belts according to National Highway Traffic Safety Administration (NHTSA) investigators.[5,6] As a result of braking before impact, the children probably moved forward very close to air bag modules at the time of deployment, and most died from neck injuries. Only 2 deaths of children (both aged 5 years) thought to have been using both lap and shoulder belts have been attributed to passenger air bags. Three deaths of adults are believed to have been caused by a passenger air bag, 2 elderly women (aged 66 years and 98 years) and a 57-year-old man.[5] These deaths occurred because the energy required to inflate an air bag in a fraction of a second to protect an unbelted occupant in a severe frontal crash can cause serious injuries to out-of-position occupants if they are close to the bag as it begins to inflate.

See also p 1418.

With these serious adverse effects identified, it is important to determine the extent to which passenger air bags are saving lives. This study provides initial estimates of passenger air bag effectiveness using data from the Fatality Analysis Reporting System (FARS).

Methods

The FARS data for calendar years 1992 through 1995 were used for this analysis.[8] FARS is a census of all fatal motor vehicle crashes occurring on public roads in the United States in which the death occurred within 30 days of the crash. The study population consisted of right front passengers killed in 1992 through 1995 model year cars with dual air bags or driver-only air bags that were in crashes during the calendar period 1992 through 1995. Crashes involving more than 2 vehicles, which account for 7% of all fatal passenger vehicle crashes,[8] were excluded because of the multiple impacts to 1 vehicle that often occur in these crashes. Single-vehicle noncollision events, such as immersion or gas

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inhalation, also were excluded. Study vehicles included cars and passenger vans but excluded other types of passenger vehicles (pickup trucks, utility vehicles). Cars with driver-only air bags and dual air bags were identified from their vehicle identification numbers using a computer program developed by the Highway Loss Data Institute.[9]

Passenger air bag effectiveness was assessed based on the location of damage to cars in which right front occupant fatalities occurred. Air bags are designed to protect occupants in frontal and front-angle crashes, not crashes at other impact locations.[3] Air bags will deploy only if there is significant deceleration in the longitudinal axis of the vehicle. Most deployments involve impacts to the front or front corners of the vehicle. Thus, if passenger air bags reduce deaths in frontal crashes, the relative frequency of right front passenger fatalities in frontal vs nonfrontal crashes should be lower in cars with dual air bags than in cars with driver-only air bags. Frontal damage was defined as initial or principal location of impact at clock positions 10, 11, 12, 1, or 2. Although clock positions 10 and 2 refer to impacts on the sides of passenger vehicles, they are defined as frontal collisions for this analysis because many of them involve a frontal force component.[3] Nonfrontal crashes are defined as all other impact locations, including overturns and vehicles with unknown impact locations.

The distribution of impact locations—frontal vs nonfrontal—was compared for cars with dual air bags and cars with driver-only air bags that were involved in crashes in which the right front passenger died. The number of right front passengers who died in fatal frontal crashes was divided by the number who died in fatal nonfrontal crashes. This number, which is the odds of death in a frontal crash, was computed separately for cars with dual air bags and cars with driver-only air bags. The odds for passenger air bag cars then were divided by the odds for driver-only air bag cars.

The percentage reductions in right front passenger deaths in frontal crashes of dual air bag vehicles were estimated by dividing the difference between the odds for dual air bag cars and for driver-only air bag cars by the odds for the driver-only air bag cars and multiplying by 100. The 95% confidence intervals (CIs) were computed for the percentage reductions in frontal crash deaths. To estimate percentage reductions in deaths in all fatal crashes, the percentage reduction in frontal crash deaths among right front occupants of dual air bag cars was multiplied by the percentage of right front passenger deaths that occurred in frontal crashes of driver-only air bag cars.

Other variables affecting crash outcomes were examined, including police-reported belt use, number of involved vehicles, and sex of the passenger. Within each category of these variables, deaths among right front passengers were compared in cars with dual air bags and with driver-only air bags. The analysis also considered various occupant age groups—0 through 9 years, 10 through 64 years, and 65 years or older—because individual crash investigations indicated that children and the elderly may be more susceptible to air bag–induced injuries.[6]

The number of deaths prevented among right front passengers in dual air bag cars was estimated by computing an expected number of deaths in frontal crashes if dual air bag cars had the same frontal to nonfrontal odds as driver-only air bag cars. The number of observed frontal crash deaths was then subtracted from the number of expected deaths to estimate the net number of deaths prevented.

This method of analysis, which is similar to the location-of-damage analysis used in previous studies to assess driver air bag effectiveness,[1,2,4] assumes that air bags have no effect on deaths in nonfrontal crashes. Another assumption is that other temporal trends did not affect the occurrence of frontal and nonfrontal fatal crashes differently. Although cars with driver-only air bags are older, on average, than cars with dual air bags, this potential confounding effect is minimized by restricting cars in the study to model years 1992 through 1995. Only fatal collisions were studied because collisions that would have been fatal in the absence of air bags or other protective factors cannot be identified.

Results

In the years 1992 through 1995, a total of 336 right front passengers in dual air bag cars (model years 1992 through 1995) died in frontal crashes, and 288 died in nonfrontal crashes. In cars with driver-only air bags (model years 1992 through 1995), 668 right front passengers died in frontal crashes, and 470 died in nonfrontal crashes.

The Table shows percentage reductions in right front passenger fatalities in cars with dual air bags. The odds of right front passengers dying in crashes with frontal impacts to those with nonfrontal impacts were 1.17 for dual air bag cars and 1.42 for driver-only air bag cars. Thus, right front passenger fatalities were 18% (95% CI, 0%-33%) fewer than expected in frontal crashes of cars with dual air bags.

For all fatal crashes (frontal and nonfrontal), deaths were 11% lower among right front passengers in cars with dual air bags. From 1992 through 1995, it is estimated that 73 fewer deaths occurred among right front passengers with dual air bags in 1992 through 1995 model cars in 1-vehicle and 2-vehicle crashes. This is the *net* benefit, accounting for deaths prevented by air bags as well as deaths caused by air bags.

Comparing right front passengers reported by police to have been using seat belts in cars with dual air bags to right front belt users in cars with driver-only air bags, fatalities in frontal crashes were reduced by 14% in cars with passenger air bags. Among right front passengers reported to be unbelted or for whom belt use was unknown, the reduction was 23% in cars with dual air bags.

Females in cars with dual air bags had a 12% reduction in frontal crash deaths and males had a 23% reduction. Analysis by passenger age shows that air bags reduced fatalities among right front passengers aged 10 years to 64 years by 24% in frontal crashes. However, among children younger than 10 years, fatalities were 34% *higher* (95% CI, −249% to 49%) than expected in frontal crashes. The deaths of 3 infants and 11 children were attributed to air bags during the calendar period of the study.[5] A modest 6% reduction in deaths was observed among passengers aged 65 years or older. Reductions in frontal crash deaths among cars with dual air bags were 20% in 1-vehicle and 15% in 2-vehicle crashes.

Comment

Initial estimates of passenger air bag effectiveness suggest they have substantially reduced fatalities among right front passengers in frontal crashes. These results are similar to those of Kahane,[3] who also reported that passenger air bags reduced deaths in frontal crashes. However, fatalities among children younger than 10 years were higher in cars with dual air bags than in cars with driver-only air bags. This finding is consistent with individual crash investigations that found passenger air bags can kill children in the right front seat in low-severity crashes.[5] Because of small sample sizes, these estimates of percentage reductions in deaths have wide CIs, and the estimate of 73 deaths prevented in vehicles with passenger air bags during the years 1992 through 1995 is associated with a high degree of statistical uncertainty. Estimates of air bag effectiveness may change somewhat when more calendar years of data are added.

The effectiveness estimates based on reported belt use should be interpreted with caution because information on belt use in crashes, even fatal ones, often is

Percentage Reductions in Right Front Passenger Deaths in Frontal and All Crashes for 1992 Through 1995 Model Year Cars and Passenger Vans With Dual Airbags, 1992 Through 1995*

Study Variable	Right Front Passenger Deaths in Frontal Crashes		Right Front Passenger Deaths in Nonfrontal Crashes		Odds of Right Front Passenger Death in Frontal Crash		Reductions of Right Front Passenger Deaths for Dual Airbags	
	Dual Airbag	Driver Airbag	Dual Airbag	Driver Airbag	Dual Airbag	Driver Airbag	Frontal Crashes, % (95% CI)	All Crashes, %
All	336	668	288	470	1.17	1.42	18 (0 to 33)	11
Reported belt use								
Used	152	339	133	256	1.14	1.32	14 (−15 to 35)	8
Not used or unknown	184	329	155	214	1.19	1.54	23 (−2 to 41)	14
Number of vehicles involved								
1	165	247	146	174	1.13	1.42	20 (−7 to 41)	12
2	171	421	142	296	1.20	1.42	15 (−11 to 35)	9
Sex†								
Female	178	395	141	275	1.26	1.44	12 (−15 to 33)	7
Male	157	272	145	194	1.08	1.40	23 (−3 to 42)	13
Age†								
0-9 y	22	28	10	17	2.20	1.65	−34 (−249 to 49)	−21
10-64 y	228	434	218	317	1.05	1.37	24 (3 to 40)	14
≥65 y	85	205	60	136	1.42	1.51	6 (−40 to 37)	4

*Frontal damage defined as initial and/or principal location of impact at clock positions 10, 11, 12, 1, and 2; CI indicates confidence interval.
†Sex or age was unknown for some occupants.

inaccurate.[10] Belt use tends to be overreported by police officers,[10] possibly more so among survivors of crashes. Because only fatally injured occupants were studied, belt use data in this study may be less affected by overreporting.

Although initial estimates suggest that the net effect of passenger air bags is more lives saved than lost, they also suggest that more children are being killed than are being saved by air bags. It is unacceptable for children to lose their lives in low-severity crashes that they would have otherwise survived. Countermeasures to reduce the number of infants and children killed or seriously injured by air bags are needed immediately. According to the results of crash investigations, child deaths to date have involved mostly unbelted or improperly belted children. Stronger restraint-use laws and active enforcement of such laws should reduce child air bag injuries, as shown in other studies of vigorous belt law enforcement.[11-15] Travel in the rear seat also should be strongly encouraged because it provides substantial reductions in risk of death among children whether or not vehicles have passenger air bags.[16]

Adults at highest risk of air bag–related injuries are those who are positioned close to the air bag at the time of deployment, particularly shorter adults and adults who ride unbelted.[17] The risk of air bag-related injuries and all other motor vehicle injuries can be greatly reduced by using seat belts and moving the seats as far away as possible from the steering wheel and dashboard.[18] The recommended minimum distance between a driver's chest and the steering wheel is at least 25 cm (10 in).[18,19]

Programs to increase correct restraint use should combine both education and enforcement because such programs are more effective than those that rely solely on education.[12] Modifications in air bag technology also are needed. Making air bag inflators deploy with less force should reduce, but not eliminate, the risks to children and can be readily developed by car manufacturers in the near future. The NHTSA recently issued a standard to allow, but not require, lower-energy air bag inflators,[20] and some car manufacturers are installing these lower-energy inflators starting with model year 1998 vehicles. In the longer term, more sophisticated air bags are being developed that will detect occupant characteristics and crash severity and then tailor deployment characteristics to maximize protection for all occupants regardless of their sizes or sitting positions.

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JAMA **Abstracts - November 5, 1997**

Editor's Note

Reductions in Deaths in Frontal Crashes Among Right Front Passengers in Vehicles Equipped With Passenger Air Bags

Elisa R. Braver, PhD; Susan A. Ferguson, PhD; Michael A. Greene, PhD; Adrian K. Lund, PhD

Context.—Virtually all new cars now are equipped with passenger air bags. Determining whether passenger air bags are saving lives is important, particularly because passenger air bags have caused some deaths among children and adults.

Objective.—To assess the effectiveness of passenger air bags in reducing the risk of death in frontal crashes for right front passengers.

Design.—Air bags are designed to protect occupants in frontal crashes. Using Fatality Analysis Reporting System data for calendar years 1992 through 1995, the relative frequency of right front passenger deaths in frontal vs nonfrontal fatal crashes was compared for cars with dual air bags and for cars with driver-only air bags.

Main Outcome Measures.—Odds of right front passengers dying in frontal compared with nonfrontal fatal crashes were computed for 1992 through 1995 model year cars with dual air bags and for cars with driver-only air bags. Percentage reductions in right front passenger deaths in dual air bag vehicles were estimated.

Results.—Right front passenger fatalities were 18% lower than expected in frontal crashes of cars with dual air bags and 11% lower in all crashes. An estimated 73 fewer than expected right front passengers died in 1992 through 1995 model cars with dual air bags during 1992 through 1995. The risk of frontal crash death for right front passengers in cars with dual air bags was reduced 14% among those reported to be using belts and 23% among belt nonusers. Children younger than 10 years in cars with dual air bags had a 34% *increased* risk of dying in frontal crashes.

Conclusions.—Passenger air bags were associated with substantial reductions in fatalities among right front passengers in frontal crashes. However, more children are being killed than are being saved by air bags. Immediate countermeasures to reduce the dangers of air bags to children and adults are suggested.

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From the Insurance Institute for Highway Safety, Arlington, Va.

EDITOR'S NOTE.—This analysis shows that, on balance, passenger air bags are beneficial. It estimates that 74 lives were saved by passenger air bags during 1992 through 1995. However, the study also found that young children traveling in the front seat are more likely to be harmed than helped by passenger air bags. The risk of injury from a deploying air bag is probably related to positioning of the automobile passenger. In this study, most fatally injured passengers were out of position because they were not wearing safety belts. However, some children who were belted were apparently positioned in harm's way just because of their small size. Although this study was unable to demonstrate an increased risk for small adults, a reasonable recommendation is that children and small adults, even if belted, should not ride in the front passenger seat of an automobile equipped with a passenger air bag.

Thomas B. Cole, MD, MPH, Contributing Editor

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Editor's Note

The Cost-effectiveness of Air Bags by Seating Position

John D. Graham, PhD; Kimberly M. Thompson, ScD; Sue J. Goldie, MD, MPH; Maria Segui-Gomez, MD, MPH; Milton C. Weinstein, PhD

Context.—Motor vehicle crashes continue to cause significant mortality and morbidity in the United States. Installation of air bags in new passenger vehicles is a major initiative in the field of injury prevention.

Objective.—To assess the net health consequences and cost-effectiveness of driver's side and front passenger air bags from a societal perspective, taking into account the increased risk to children who occupy the front passenger seat and the diminished effectiveness for older adults.

Design.—A deterministic state transition model tracked a hypothetical cohort of new vehicles over a 20-year period for 3 strategies: (1) installation of safety belts, (2) installation of driver's side air bags in addition to safety belts, and (3) installation of front passenger air bags in addition to safety belts and driver's side air bags. Changes in health outcomes, valued in terms of quality-adjusted life-years (QALYs) and costs (in 1993 dollars), were projected following the recommendations of the Panel on Cost-effectiveness in Health and Medicine.

Participants.—US population-based and convenience sample data were used.

Main Outcome Measure.—Incremental cost-effectiveness ratios.

Results.—Safety belts are cost saving, even at 50% use. The addition of driver's side air bags to safety belts results in net health benefits at an incremental cost of $24,000 per QALY saved. The further addition of front passenger air bags results in an incremental net benefit at a higher incremental cost of $61,000 per QALY saved. Results were sensitive to the unit cost of air bag systems, their effectiveness, baseline fatality rates, the ratio of injuries to fatalities, and the real discount rate.

Conclusions.—Both air bag systems save life-years at costs that are comparable to many medical and public health practices. Immediate steps can be taken to enhance the cost-effectiveness of front passenger air bags, such as moving children to the rear seat.

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From the Center for Risk Analysis, Harvard School of Public Health, Boston, Mass.

EDITOR'S NOTE.—Preventive strategies should not be undertaken unless they have been shown to be effective in reducing morbidity or mortality or improving the quality of life. Among strategies found to be effective, some offer greater value than others. The authors of this study estimated the cost-effectiveness of air bags, using the best available data and a rigorous analytic method. Estimates for the cost-effectivness of seat belts alone, seat belts plus a driver's side air bag, and seat belts plus a dual air bag system were computed and adjusted for possible errors in the underlying assumptions of the analysis. There were large differences in the estimated cost-effectiveness of the 3 occupant protection systems evaluated.

Thomas B. Cole, MD, MPH, Contributing Editor

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