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HIGHWAY SAFETY

Have Automobile Weight Reductions Increased Highway Fatalities?

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The Honorable Ernest F. Hollings
Chairman
Committee on Commerce, Science, and Transportation
United States Senate

The Honorable Richard H. Bryan
Chairman
Consumer Subcommittee
Committee on Commerce, Science, and Transportation
United States Senate

On April 11, 1991, I appeared before the Consumer Subcommittee of the Senate Committee on Commerce, Science, and Transportation to describe the preliminary results of our work on the relationship between automobile weight and highway fatalities. On June 13, 1991, you requested that we prepare an updated report on the results of our continuing research effort since that time. In response to your request, this report presents one portion of our recent work, an analysis of the effect that the "downsizing" of automobiles since the mid-1970's has had on highway fatalities.

The Motor Vehicle Fuel Efficiency Act (S. 279) and other recent proposals to increase corporate average fuel economy (CAFE) standards have drawn renewed attention to the debate over automobile size and safety that was vigorously pursued from the early 1970's until the mid-1980's. In the context of the CAFE debate, it has been argued that more stringent fuel efficiency standards can be achieved—at least in the short term—only if automobile manufacturers build and sell smaller cars than they do now. Smaller cars, the argument continues, are less safe than larger cars, and the automobile fatality rate will therefore increase if more small cars appear on America's roadways.

This projection about the negative highway safety consequences of future automobile downsizing is derived from research performed on the effects of past automobile weight reductions among specific makes and models of cars, or in particular types of accidents. This research has focused on crashworthiness—that is, the protection that cars of different sizes afford their occupants in the event of a collision. On the basis of this research, the National Highway Traffic Safety Administration (NHTSA) testified before the Consumer Subcommittee that over 1,300 fatalities each year can be attributed to the automotive weight reductions that began in the 1970's (NHTSA, 1991a).[1]

In my testimony before the Subcommittee, I noted that highway fatalities declined over the past decade at the same time that the average weight of cars on the road was also declining. This fact does not in itself disprove the contention that lighter cars are inherently more dangerous, but it justifies a closer examination of the support for this contention. Accordingly, we reviewed the research literature on automobile weight and safety, particularly the technical reports issued by NHTSA. We also conducted our own analysis of data from the Fatal Accident Reporting System (FARS), a data set of fatal traffic accidents that is maintained by NHTSA.

Results in Brief

The unprecedented increase in the proportion of light cars on the road since the 1970's has not increased the total highway fatality rate (that is, the number of automobile occupant deaths per 100,000 registered cars). Our findings support the view that the automobile weight reductions since the mid-1970's have had virtually no effect on total highway fatalities. Fatality rates for all cars have declined in recent years, but the rate for light cars has improved more than that for heavier cars. We found that an approach that focuses exclusively on crashworthiness neglects other important factors involved in the weight/safety relationship that may have had beneficial effects on highway safety during the 1970's and 1980's. One of these factors is the dramatic reduction in the number of heavy cars, and therefore in the danger that these cars pose to occupants of other vehicles with which they collide.

Our Analysis

In order to examine changes in the weight/safety relationship, we analyzed fatality data from two periods: (1) the years 1976-78, which marked the early stages of a period of rapid downsizing, and (2) the years 1986-88, an interval marking the end of that downsizing movement. Our work focused solely on testing the contention that lighter cars have a negative impact on overall highway safety; we did not address the question of whether more stringent CAFE standards can be achieved only by building lighter cars.

[1]In a later research summary, NHTSA stated that "nearly 2,000" fatalities annually are due to downsizing. We estimate that NHTSA's methodology, if it were applied to all types of accidents, would ascribe between 3,115 and 5,410 fatalities per year to downsizing. (See appendix IV.)

The terms "downsizing" or "car size" can refer to several measures of automobile size, including weight, length, and width, as well as other indicators of size. We limited our analysis of the effects of downsizing to an examination of weight changes and their relationship to fatalities. Weight is the aspect of automobile size most closely related to fuel efficiency and is, therefore, the most appropriate measure in the context of the CAFE debate.

We found that the median weight of 1- and 2-year-old cars decreased an average of nearly 1,100 pounds between 1975 and 1988. However, this decrease was not proportionate across weight groupings; rather, it was concentrated primarily among the heaviest cars. Cars over 4,000 pounds represented nearly 40 percent of new cars in the 1970's, but less than 3 percent in the 1980's. The weight of cars at the lower end of the weight spectrum changed very little during this period.

The fatality rate for both single and multiple vehicle accidents declined during this period, but this decline also was not proportionate across weight groupings. In the 1970's, the highest occupant fatality rate was sustained by cars under 2,000 pounds. This rate declined some 56 percent over the decade. In both the 1970's and the 1980's, cars in the middle of the weight distribution scale had higher fatality rates than cars in some lower weight categories. This was particularly true for the 1980's, when cars weighing between 2,501 and 3,000 pounds had the highest fatality rate among our weight categories.

When we examined the fatality rates of our lightest weight category, we discovered that a large proportion of the fatalities occurred in the very lightest cars. In the 1980's, cars weighing 1,800 pounds or less, which represented less than one half of 1 percent of cars on the road, had a fatality rate more than twice as high as cars between 1,801 and 2,000 pounds. This finding suggests the possibility of a weight threshold below which fatality rates increase sharply. However, such a conclusion must remain tentative, since so few cars of this type are on the road that a very few fatal accidents could cause wide fluctuations in their fatality rate.

We have not fully examined the way in which other vehicle-design or driver characteristics may affect safety, but our preliminary review of how driver age varies across car weight categories suggests that this factor may cause an artificial inflation of fatality rates among lighter cars. Young drivers are involved disproportionately in fatal accidents, and drivers under 25 years of age in fatal accidents are much more likely to operate lighter cars than heavier ones. It is likely, therefore, that some portion of the fatalities in lighter car categories should be attributed to driver age rather than to automobile weight.

The additional research we have performed since my testimony before your committee has not altered the conclusion I reported at that time—that is, that the relationship between car size and safety is neither a simple nor a linear one. Fatality rates do not increase simply because cars get lighter. Further, the dramatic increase in the proportion of light cars since the mid-1970's has not increased the total highway fatality rate. While many factors have contributed to lower fatality rates over the past decade—among them, safety requirements imposed by NHTSA—it is critical to recognize that the decrease in the number of heavy cars has itself diminished the danger to occupants of other cars on the road.

The attached appendixes provide a more detailed exposition of our study, including the details of our methodology and a discussion of the relationship between young drivers and fatality rates.

We provided draft copies of this report to NHTSA officials and discussed the study results with them. We have incorporated their suggestions where appropriate. We plan no further distribution of this report until 30 days from its date of issue, unless you publicly announce its contents earlier. At that time, we will send copies to the Secretary of Transportation. We will also make copies available to interested organizations, as appropriate, and to others upon request.

If you have any questions or would like additional information, please call me at (202) 275-1854 or Mr. Kwai-Cheung Chan, Director of Program Evaluation in Physical Systems Areas, at (202) 275-3092. Other major contributors to this report are listed in appendix V.

Eleanor Chelimsky
Assistant Comptroller General

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Abbreviations

CAFE	Corporate average fuel economy
FARS	Fatal Accident Reporting System
GAO	General Accounting Office
NHTSA	National Highway Traffic Safety Administration

The Effect of Automobile Weight Reductions on Highway Fatalities

Introduction

The Motor Vehicle Fuel Efficiency Act (S. 279) and other recent proposals to increase corporate average fuel economy (CAFE) standards have drawn renewed attention to the debate about automobile size and safety that was vigorously pursued from the early 1970's until the mid-1980's. In the context of the CAFE debate, it has been argued that more stringent fuel efficiency standards can be achieved—at least in the short term—only if automobile manufacturers build and sell smaller cars. However, smaller cars, it is argued, are less safe than larger cars, and the automobile fatality rate will therefore increase if more small cars appear on America's roadways. The National Highway Traffic Safety Administration (NHTSA) has been a forceful proponent of this position: "Any government fuel conservation legislation that forces a significant reduction in car size can be expected to increase the number of deaths and cause injuries" (NHTSA, 1991d).

Projections concerning the negative highway safety consequences of future automobile downsizing have been produced by aggregating the results of separate studies about the effects of past automobile weight reductions among specific makes and models of cars, or in particular types of accident. This research has focused on the relationship between automobile weight and injury risk in the event of a collision, particularly crashworthiness—that is, the protection that cars of different sizes afford their occupants in a crash. However, it has failed to take full account of other potential effects of automobile weight reductions that may have beneficial effects on highway safety, in particular by reducing the danger that heavy automobiles pose to other roadway users.

Our goal here was to examine the contention that automobile weight reductions have increased the highway fatality rate. We did so by examining the relationship between automobile weight and highway fatalities at two points in time: (1) the years 1976-78, at the early stages of what turned out to be a period of rapid automobile downsizing, and (2) the years 1986-88, an interval at the end of that downsizing movement. (See appendix II.) Our work was focused solely on the relationship between car weight and overall highway safety; we did not address the question of whether more stringent CAFE standards can be achieved only by building lighter cars.

Automobile Size and Its Relationship to Safety

The terms "downsizing" and "car size" can refer to several measures of automobile size, including weight, length, and width, as well as other indicators of size. To avoid this imprecision, it is important to note that for our analysis we defined size as weight. Weight is the aspect of automobile size that is most closely related to fuel efficiency and is, therefore, the most appropriate measure in the context of the CAFE debate. The several measures of size, however, tend to vary together—for example, heavier cars tend to be longer and wider than lighter ones—and it is sometimes difficult to isolate, for analytic purposes, the effects of one measure from another (Kahane, 1989).

The effect of size that comes most easily to mind involves occupant protection, or crashworthiness. It is generally accepted that larger automobiles offer more protection to their occupants in the event of a collision than do smaller ones. (See, for example, Evans, 1982, 1985a; Robertson, 1991.) Crashworthiness, however, is more directly linked to exterior size (usually measured as wheelbase, the distance between the axles), or to "crush space" (the amount of material capable of absorbing the impact of a crash before it reaches the vehicle occupants), or to other safety features designed to protect occupants, than it is to weight. Weight is related to crashworthiness to the extent that these other physical dimensions of a vehicle tend to correlate with an increase in its weight.

The second effect of size is a specific function of car weight itself and is sometimes termed aggressivity. Heavier cars are more "aggressive"—that is, they transfer more energy at a given velocity than do smaller automobiles when they hit a fixed object. In the case of multivehicle collisions, a heavier car hits the other vehicles with more force than would a lighter one. (See, for example, O'Neill, Joksch, and Haddon, Jr., 1974.) For instance, a 3,500 pound car traveling 35 miles per hour has about as much energy at impact as a 2,000 pound automobile whose velocity is 46 miles per hour.

Finally, a vehicle's weight can also affect its accident involvement rate. Researchers have clearly demonstrated one example of this effect. Cars that are lighter, narrower, and have a high center of gravity are at higher risk of rollover than other automobiles (Mengert et al., 1989; Robertson and Kelley, 1989). Cars that roll over relatively easily are likely to cause more occupant fatalities than those that do not (Kahane, 1989).[1] However, considering both single-car and multivehicle accidents together, other researchers have found that lighter cars have a lower overall accident involvement rate than heavier cars after driver characteristics are accounted for. (See, for example, Evans, 1985b and 1985d.) In fact, Evans (1984) estimated that if all cars were driven by drivers of the same age, cars of roughly 4,000 pounds would have an accident involvement rate approximately 39 percent higher than cars weighing about 2,000 pounds.

Changes in Automobile Weight and Fatality Rates, 1975-88

The outlook that has commanded the most attention in the current renewal of the small car safety debate views safety from the perspective of occupants of individual cars and focuses on the protective aspect of automobile size. This position holds that light cars are inherently more dangerous for their occupants than heavier autos. (See, for example NHTSA, 1991b.) Thus, explanations of the effects of past automobile weight reductions, or estimates of the likely effects of future downsizing, focus on the risk to occupants of downsized vehicles. For example, the Insurance Institute for Highway Safety (1990a) estimated that the weight and size reductions of 11 models of General Motors cars from 1977 to 1986 produced fatality rates for occupants of those vehicles that were 23 percent greater than they would have been without downsizing. Similarly, NHTSA aggregated the findings from a series of studies about particular types of accidents to derive the estimate that "nearly 2,000" occupants of downsized cars are killed each year who would not die if cars had remained as large as they were in 1975 (NHTSA, 1991b).[2]

Thus, from this perspective, increases in the proportion of light cars on the road should increase roadway fatalities substantially, assuming that all other factors remain the same. Since occupant risk is seen as inherently a function of automobile size, this view presumes that the relative danger of different sized cars does not change—that is, there is no

[1] However, the relationship between rollover propensity and occupant injuries and fatalities is not a simple one. Kahane (1989) and Partyka and Boehly (1989) found that the relationship between rollover and injury probability changes with car size. Occupants of light cars are less likely to be injured as the result of a rollover than are the drivers of heavier cars. The reason for this is that large cars roll over less easily and the relatively greater "crash force" required to overturn a heavier car leads to an increased probability of injury.

[2] The figure of "nearly 2,000" additional fatalities due to downsizing actually substantially understates the cumulative effect of NHTSA's separate estimates. We project that NHTSA's estimates actually sum to between 3,115 and 5,410 additional annual fatalities—between 13 and 23 percent of all automobile occupants killed. (See appendix IV.)

reason to expect a shift over the years in the degree of higher risk associated with lighter cars in comparison to heavier ones, for example.

Our first step in evaluating this perspective was to examine how car weights and fatality rates have changed over the period 1975-88.[3]

Average Weight of Automobiles

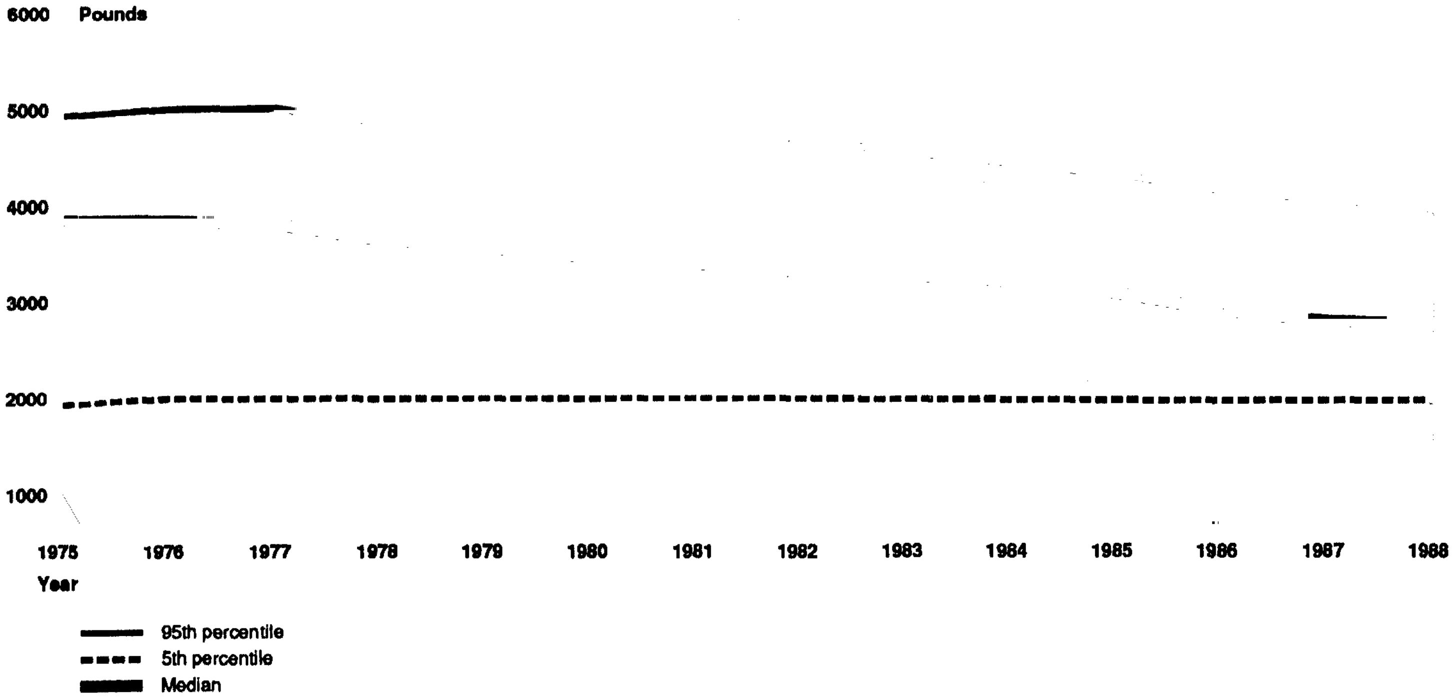
As figure I.1 indicates, the median weight of passenger cars on America's roadways decreased by approximately 28 percent between 1975 and 1988.[4] We estimate that the 50th percentile car in 1988 weighed about 2,752 pounds, or 1,086 pounds less than in 1975.[5]

[3]Fatality rate is defined here as the number of automobile occupants killed per 100,000 automobiles registered. (For complete details on our methodology, see appendix II.)

[4]These years were chosen because they are the years for which we have comparable weight, fatality, and automobile registration data. (See appendix II.)

[5]These figures are only for cars 9 or fewer years old at each calendar year. They overestimate to some degree the decline in automobile weights because cars more than 9 years old are relatively heavy compared with newer automobiles.

Figure I.1: Changes in Automobile Weight, 1975-88



Range of Automobile Weights

Figure I.1 also shows that the range of automobile weights decreased significantly during the period. The reduced variability of automobile weights means that the average weight difference between any pair of cars was much smaller in 1988 than in 1975. The upper line on the figure marks the weight of the 95th percentile car for each year, while the lower line represents the weight of the 5th percentile car; ninety percent of all cars on the road for each year fall between those two lines. In 1975, the difference between the weights of the 95th and 5th percentile cars was more than 3,000 pounds; by 1988, that difference had decreased to less than 2,000 pounds.[6] More importantly, the decrease was accomplished by reductions in the weight of the largest cars; cars at the low end of the weight distribution were actually slightly heavier in 1988 than in 1975.

[6]The mean weight declined from 3,707 pounds in 1975 to 2,830 pounds in 1988, and the standard deviation of the weights decreased from 892 pounds in 1975 to 619 pounds in 1988.

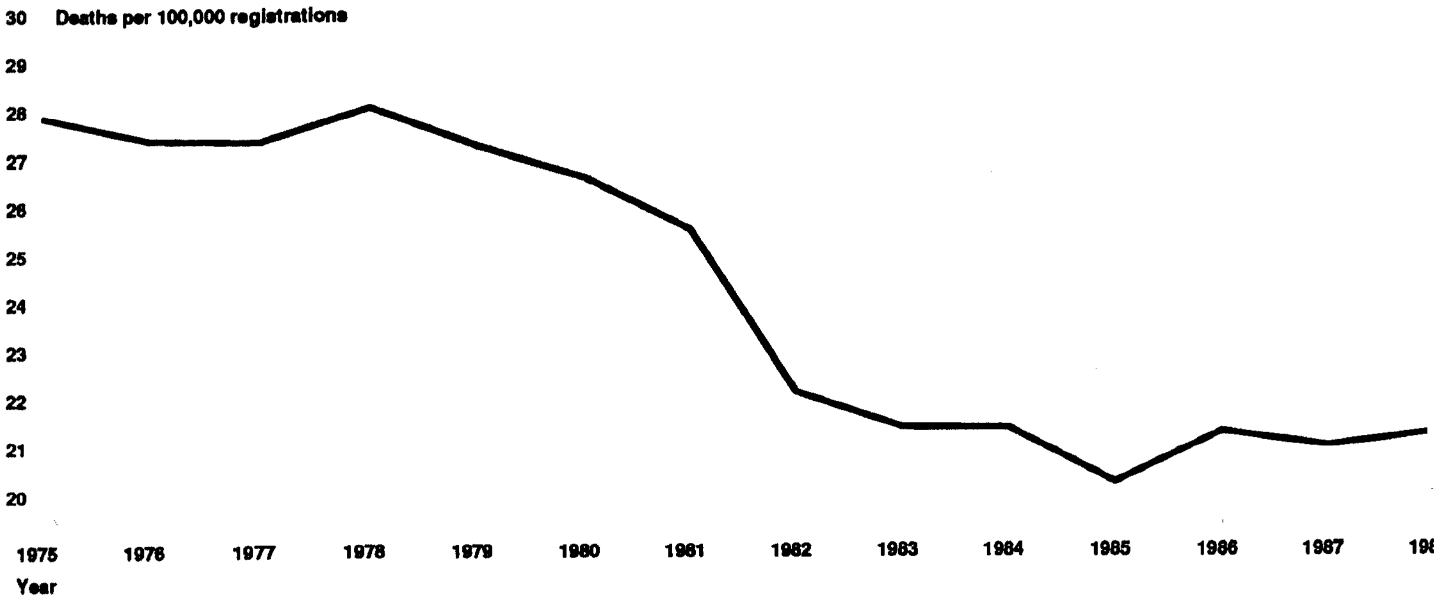
This decreased weight range may have important safety implications because of the aggressivity effect discussed earlier. (See, for example, Miller, 1974.) For any two-car accident involving cars that do not weigh the same, the decrease in the weight range means that occupants of the smaller vehicle have less to fear from the "aggressive" force of the larger, but now relatively less heavy, vehicle hitting theirs. Even assuming no change between 1975 and 1988 in the protective ability of the lighter car in each accident, this factor by itself may contribute to a reduction in deaths resulting from two-car accidents.[7]

Automobile Occupant Fatality Rates

The overall automobile occupant fatality rate declined by more than 20 percent between 1975 and 1988. (See figure I.2.) The figure shows that the fatality rate for passenger car occupants decreased from approximately 28 deaths per 100,000 registered autos in 1975 to roughly 21 per 100,000 registrations in 1988 (GAO, 1990). This decline in passenger car fatality rates during a period of rapid automobile downsizing does not mean that the move toward lighter cars has actually saved lives, since many potential influences on highway safety that are not related to automobile weight also changed between 1975 and 1988. Among other factors, these include improvements in automobile and roadway design, a reduction in the proportion of young drivers on the road due to the changing age distribution of the population, the increased use of safety belts, and the heightened attention of the public and law enforcement to the issue of drunk driving. (See, for example, Hedlund et al., 1984; NHTSA, 1991b.) However, this trend of decreasing fatalities does make it more difficult to support the assertion that car weight reductions have increased fatalities.

[7]Two other changes in the weight of the vehicle fleet also may have had an effect on safety, but their net effect cannot be precisely estimated. First, the number of light trucks on the road increased more than twice as fast as the number of passenger cars. These relatively heavier vehicles have a negative aggressivity impact on safety, and themselves have higher occupant fatality rates than automobiles. Second, the number of older (and usually heavier) cars on the road has increased as consumers keep their cars longer.

Figure I.2: Automobile Occupant Fatality Rates, 1975-88



Comparisons Between New Cars in 1976-78 and 1986-88

In order to investigate the relationship between car weight and fatality rates in greater detail, and to determine whether that relationship has changed over time, we compared two fleets of vehicles: 1- and 2-year old cars on the road in 1976-78, and 1-and 2-year old cars in 1986-88. For this analysis, we divided the cars into weight categories at 500 pound intervals. The auto weight categories ranged from 2,000 pounds or less for the lightest cars through 5,001 to 5,500 pounds for the heaviest. In the following sections, we will

- describe how downsizing affected the distribution of cars into weight categories,
- present changes in the overall fatality rate,
- characterize the fatality rates for different types of accidents,
- list the fatality rate for each auto weight category in each type of accident, and
- look more closely at fatalities in the very lightest cars.

Proportion of Light Cars

Table I.1 documents the striking effects of downsizing. The most numerous cars in 1976-78, those between 4,001 and 4,500 pounds, dropped precipitously as a percentage of all 1- and 2-year-old cars, from 21.3 percent of the total then to less than 3 percent 10 years later. In addition, cars over 4,501 pounds, 18 percent of the total in 1976-78, had disappeared by 1986-88. Conversely, cars between 2,001 and 3,000 pounds registered dramatic gains. The proportion of cars in the 2,001 to 2,500 pound category more than tripled to 34 percent in 1986-88, while the percentage of cars in the 2,501 to 3,000 pound group nearly doubled to 27 percent. However, the smallest cars, those weighing 2,000 pounds or less, showed only a nominal increase, from 4.2 to 5.3 percent of the total. Overall, about two thirds of all cars weighed 3,000 pounds or less in 1986-88, compared with only 28 percent in 1976-78.

Table I.1: Automobile Weight Category Distribution Percentages, 1976-78 and 1986-88

Weight category[a]	1976-78	1986-88	Percent change
2,000 or less	4.2	5.3	26
2,001 to 2,500	9.4	34.1	263
2,501 to 3,000	14.1	27.1	92
3,001 to 3,500	17.5	20.9	19
3,501 to 4,000	15.3	9.8	−36
4,001 to 4,500	21.3	2.8	−87
4,501 to 5,000	9.8	[b]	[b]
5,001 to 5,500	8.4	[b]	[b]

[a]In pounds

[b]In 1986-88, this weight category contained no cars.

Fatality Rates for Different Types of Accident

The occupant fatality rate decreased from 23.90 per 100,000 car registrations in 1976-78 to a rate of 20.87 in 1986-88, a decline of about 13 percent. Table I.2 lists the fatality rates for cars in the 1976-78 and 1986-88 data sets in different types of accidents. The table shows that the fatality rate decreased for most types of accidents. In particular, the fatality rates for the most prevalent accidents, those involving one and two cars, decreased by 22 percent. However, the fatality rate for all other accident types increased by 11 percent. These consisted of two-vehicle collisions with nonautomobiles and accidents involving three or more vehicles.

Table I.2: Occupant Fatality Rates for 1- and 2-Year-Old Cars, 1976-78 and 1986-88

Accident type	Fatality rate[a] 1976-78	Fatality rate[a] 1986-88	Percent change
One-car			
Rollover[b]	2.21	1.53	−31
Nonrollover	8.49	6.85	−19
Total	10.70	8.38	−22
Two-vehicle			
With a car 9 or fewer years old	5.54	3.40	−39
With a car 10 or more years old	1.04	1.71	64
Total	6.58	5.11	−22
With a light truck or van[c]	2.03	2.84	40
With a medium or heavy truck or a bus[c]	2.67	2.31	−13
With another vehicle[c]	0.27	0.16	−41
Involving three or more vehicles[c]	1.65	2.07	25
Total	**23.90**	**20.87**	**−13**

[a]Entries are number of deaths per 100,000 automobile registrations.

[b]We defined rollovers as primary rollovers. The variables in the FARS data sets indicating a rollover have changed over the years. For 1976-77, we coded a primary rollover if the "first harmful event" was an overturn. For 1978 and 1986-88, we coded a primary rollover if the rollover variable was coded the "first event."

[c]These are fatality rates for deaths of occupants of 1- and 2-year-old cars in collisions with other vehicles of any age.

Four other aspects of table I.2 are especially noteworthy. First, single-car rollover fatalities registered a particularly large decrease (31 percent). This may indicate an increased rate of seat belt usage—Kahane (1989) reported that about 70 percent of the fatalities in rollover accidents could be prevented by safety belts. Second, the fatality rate for two-car accidents with cars less than 10 years old declined very sharply, by 39 percent. This rate is of particular interest because these cars are a closer approximation to the future car fleet than are older cars, on the assumption that a substantial proportion of new cars will continue to be lightweight.

Third, the fatality rate for collisions with cars 10 years of age or older increased 64 percent. This change is partially a function of the increasing longevity of passenger cars that we noted earlier. The number of registered cars more than 9 years old nearly doubled during this period. The differential effect of vehicle age may also be read as a reflection of the "aggressivity" function of vehicle weight. In collisions with older, generally heavier cars, our population of 1- and 2-year-old automobiles are at a greater disadvantage than in collisions with newer, generally lighter cars. Fourth, fatality rates for collisions with light trucks and vans also increased sharply, presumably for the same reasons that account for the increased fatality rate for collisions with older cars: (1) the steep increase in the number of these vehicles on the road, and (2) the disadvantage that newer, lighter cars are at in collisions with these heavier vehicles.

Fatality Rates by Automobile Weight Category

As figures I.3 and I.4 show, fatality rates decreased for all automobile weight categories between the periods 1976-78 and 1986-88. Figure I.3 graphs fatality rates for each weight category in 1976-78 for both single- and multivehicle accidents. Figure I.4 presents the same information for 1986-88. Tables I.3 and I.4 provide a detailed enumeration of the fatality rate for each type of accident for all weight categories.

Figure I.3: Occupant Fatality Rates by Automobile Weight, 1976-78

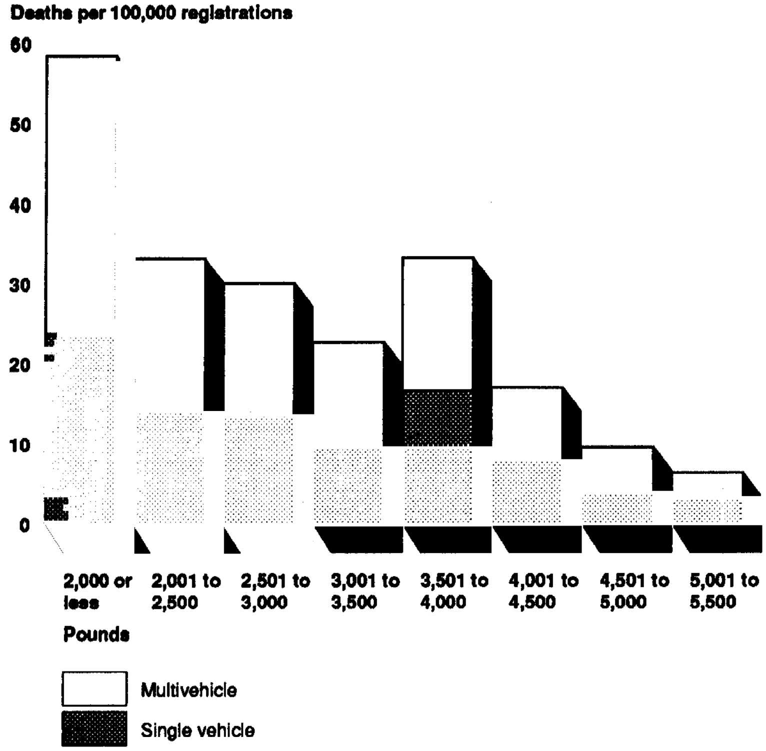


Figure I.4: Occupant Fatality Rates by Automobile Weight, 1986-88

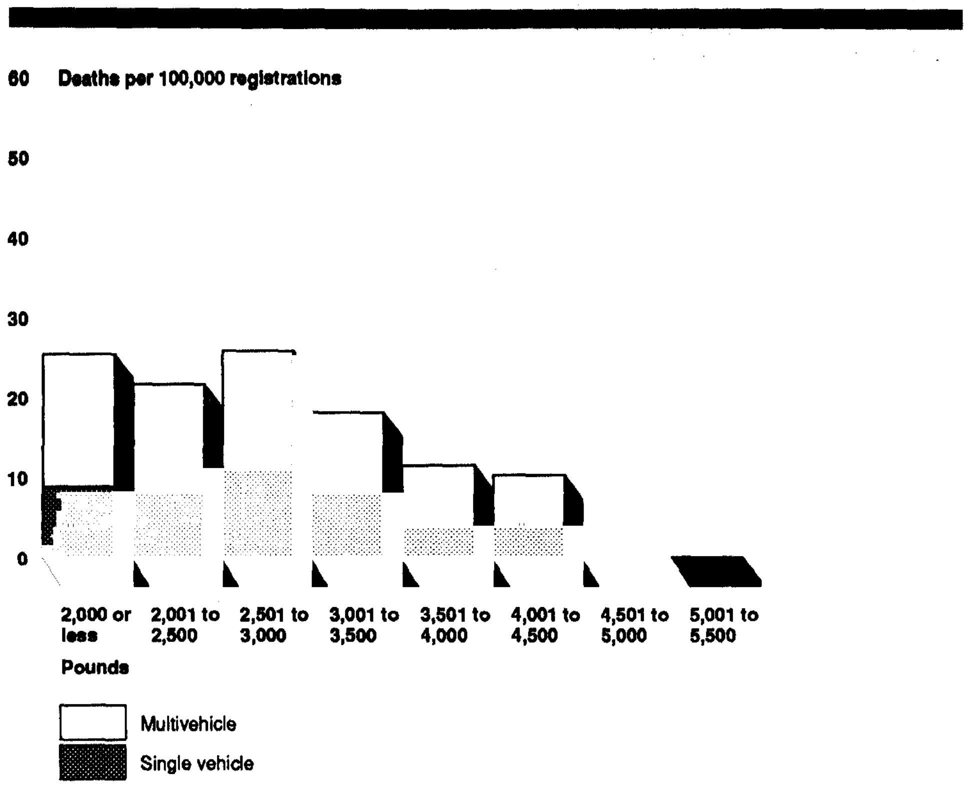


Table I.3: Occupant Fatality Rates by Automobile Weight Category, 1976-78

	Weight category[a]							
Accident type	**2,000 or less**	**2,001 to 2,500**	**2,501 to 3,000**	**3,001 to 3,500**	**3,501 to 4,000**	**4,001 to 4,500**	**4,501 to 5,000**	**5,001 to 5,500**
One-car								
Rollover[b]	7.75	3.74	3.63	1.64	2.48	1.23	0.56	0.45
Nonrollover	15.89	10.15	9.83	7.89	14.02	6.57	3.28	2.76
Total	23.64	13.89	13.46	9.53	16.50	7.80	3.83	3.21
Two-vehicle								
With a car 9 or fewer years old	16.57	8.50	7.21	5.87	6.76	3.19	1.94	1.13
With a car 10 or more years old	3.04	1.56	1.34	1.10	1.28	0.62	0.25	0.36
Total	19.61	10.06	8.55	6.97	8.04	3.82	2.19	1.49
With a light truck or van[c]	5.42	3.24	2.57	1.85	2.53	1.41	0.86	0.41
With a medium or heavy truck or a bus[c]	4.52	2.70	3.02	2.62	3.81	2.51	1.53	0.88
With another vehicle[c]	0.76	0.46	0.38	0.28	0.33	0.11	0.10	0.07
Involving three or more vehicles[c]	4.39	2.72	2.01	1.40	1.95	1.25	1.02	0.20
Total	**58.34**	**33.07**	**29.99**	**22.65**	**33.16**	**16.90**	**9.53**	**6.26**

[a]Entries are number of deaths per 100,000 automobile registrations.

[b]Rollovers are primary rollovers. The variables in the FARS data sets indicating a rollover have changed over the years. For 1976-77, we coded a primary rollover if the "first harmful event" was an overturn. For 1978 and 1986-88, we coded a primary rollover if the rollover variable was coded the "first event."

[c]These are fatality rates for deaths of occupants of 1- and 2-year-old cars in collisions with other vehicles of any age.

Table I.4: Occupant Fatality Rates by Automobile Weight Category, 1986-88

	Weight category[a]							
Accident type	**2,000 or less**	**2,001 to 2,500**	**2,501 to 3,000**	**3,001 to 3,500**	**3,501 to 4,000**	**4,001 to 4,500**	**4,501 to 5,000[b]**	**5,001 to 5,500[b]**
One-car								
Rollover[c]	1.94	1.70	1.91	1.32	0.40	0.45		
Nonrollover	6.85	6.50	9.06	6.64	3.38	3.54		
Total	8.79	8.20	10.97	7.96	3.78	3.99		
Two-vehicle								
With a car 9 or fewer years old	4.62	3.93	4.03	2.51	1.63	1.12		
With a car 10 or more years old	2.23	1.88	2.14	1.35	0.76	0.45		
Total	6.85	5.81	6.17	3.86	2.39	1.57		
With a light truck or van[d]	4.50	3.08	3.16	2.36	1.76	1.24		
With a medium or heavy truck or a bus[d]	2.20	2.26	2.80	2.00	2.07	1.69		
With another vehicle[d]	0.48	0.13	0.21	0.11	0.06	0.11		
Involving three or more vehicles[d]	2.59	2.08	2.51	1.76	1.37	1.63		
Total	**25.41**	**21.56**	**25.82**	**18.05**	**11.43**	**10.23**		

[a]Entries are number of deaths per 100,000 auto registrations.

[b]In 1986-88, this weight category contained no cars.

[c]Rollovers are primary rollovers. The variables in the FARS data sets indicating a rollover have changed over the years. For 1976-77, we coded a primary rollover if the "first harmful event" was an overturn. For 1978 and 1986-88, we coded a primary rollover if the rollover variable was coded the "first event."

[d]These are fatality rates for deaths of occupants of 1- and 2-year-old cars in collisions with other vehicles of any age.

For 1976-78, the weight category containing the lightest cars (2,000 pounds or less) had by far the highest occupant fatality rate. From there, fatality rates generally declined with increasing car weight, although there is a "hump"—that is, a departure from linearity—in the distribution for the high fatality rates of the 3,501 to 4,000 pound category. The lowest occupant death rates were in the two heaviest weight categories. For 1986-88, the differences among the weight categories were much less severe. The hump in the distribution represents the highest fatality rate; the death rate for the 2,501 to 3,000 pound category is slightly higher than the rate for cars weighing 2,000 pounds or less. Once again, the lowest occupant death rates were for cars in the two heaviest weight categories.

The most dramatic improvements occurred for cars weighing 2,000 pounds or less and for those in the 3,501 to 4,000 pound category. The fatality rate for the lowest weight category (2,000 pounds or less) was more than halved, with an improvement of 56 percent. The death rate for these cars in 1976-78, 58.34 fatalities per 100,000 registered cars, was more than twice that of the overall fatality rate of 23.90. By 1986-88, the fatality rate for this group had declined so much that it was actually slightly below the rate for cars in the 2,501 to 3,000 pound group. Among heavier cars, the fatality rate for cars weighing between 3,501 and 4,000 pounds declined even more, by about two thirds.[8]

Fatality Rates for the Lightest Cars

We conducted a more detailed analysis of the fatality rates for cars within the lightest car category (2,000 pounds or less). Within this group, we found that the very lightest cars, those weighing 1,800 pounds or less, had substantially higher occupant fatality rates than those above 1,800 pounds. For 1976-78, cars below the 1,800 pound mark had an exceedingly high fatality rate of 74.38 occupant deaths per 100,000 auto registrations per year, compared to a figure of 55.17 for cars between 1,801 and 2,000 pounds. This pattern was repeated in 1986-88, though at a lower level. The fatality rate in 1986-88 for cars at or below 1,800 pounds was 52.89; for cars 1,801 to 2,000 pounds, the rate was 22.90.

One interpretation of this result is that there may be some minimum size or weight threshold below which occupant safety declines precipitously. (For example, see Miller, 1974.) However, this finding should be viewed with particular caution since automobiles with a weight of 1,800 pounds or less were a very small percentage of all cars on the road for the years included in our data sets. Specifically, they comprise less than seven tenths of 1 percent of the cars of our 1976-78 population, and less than one half of 1 percent of our 1986-88 population. Any conclusion drawn from such a small group is at best tentative, since only a slight change in the number of deaths in this category would result in a large change in the group's fatality rate.

Summary of Findings

Our examination of changes in the weight of automobiles and in the fatality rate associated with different weight categories can be summarized as follows:

[8]It has been suggested that in 1976-78 the 3,501 to 4,000 pound category contained a disproportionate share of high performance cars with unusually high death rates, and that these cars had been downsized and distributed to other weight categories by 1986-88.

1. The median weight of automobiles on the road decreased nearly 1,100 pounds from 1975 to 1988.

2. This decrease was not proportionate across weight categories. The heaviest cars were dramatically downsized, while lighter cars experienced little weight change.

3. In 1976-78, cars under 2,000 pounds had the highest fatality rates, and the heaviest cars had the lowest. The 3,500 to 4,000 pound weight category had the second highest fatality rate.

4. In 1986-88, fatality rates for all weight categories were substantially lower than in the 1970's. The fatality rate for cars under 2,000 pounds decreased greatly. Cars between 2,501 and 3,000 pounds had the highest fatality rate, and the heaviest weight category had the lowest.

Conclusions

Several of our findings support the position that heavier cars are safer than lighter cars. Thus, we found that the very smallest cars (those weighing 1,800 pounds or less) had much higher fatality rates than larger cars. Conversely, the largest cars (those above 4,500 pounds in 1976-78 and those above 3,500 pounds in 1986-88) had the lowest occupant fatality rates, though these rates may be artificially low due to factors not related to car size (such as the small proportion of heavy cars with young drivers).[9] While the lines between these endpoints of the weight distribution are not entirely smooth, occupant fatality rates did generally decline with increasing car weight for both time periods.

However, these individual findings about the relative safety of occupants in different categories of cars do not adequately explain the overall pattern of the fatality/weight relationship and its changes between the 1970's and the 1980's. The unprecedented increase in the proportion of light cars on the road that occurred between 1976-78 and 1986-88 did not have the dire consequences for safety that would be expected if fatality rates were simply a function of car weight. Not only did the total fatality rate decrease, but the fatality rate for small cars—those at the greatest risk if it is assumed that heavier cars are inherently safer than lighter cars—also declined sharply. Thus, the fatality rate for cars weighing 2,000 pounds or less declined by 56 percent, from 58.34 to 25.41 per 100,000 auto registrations, while the occupant

[9]See appendix III.

fatality rate for all cars at or below 3,000 pounds dropped by one third, from 35.34 to 23.60.

The perspective that fatality rates are a simple function of car weight also fails to account for the relatively flat relationship between auto weight and occupant fatality rates in 1986-1988, and the change in this relationship that occurred between 1976-78 and 1986-88. The fatality rate differences among the weight groups were much greater in 1976-78 than in 1986-88, and the differences between the light car categories and the overall fatality rate were much larger in the earlier period. In order to explain this change, it is necessary to go beyond the boundaries of the simple car-weight perspective to consider changes in the distribution of automobiles between these periods. For instance, it may be that the two related changes in the automobile weight distribution that we documented earlier were contributing factors to the change in the distribution of fatality rates. The first of these changes was the constriction of the range of automobile weights. Cars were much more alike in weight in 1986-88 than they were in 1976-78. The second change was the increase in the number of small cars between these periods. Light cars may be much safer when more of them are on the road, supplanting larger, more "aggressive" automobiles.

In contrast, the pattern of our findings is consistent with an interpretation that automobile weight reductions have a net effect on total highway fatalities that is close to zero. In this view, automobile downsizing has two roughly offsetting effects, reducing both the crashworthiness effect of car size (exterior dimensions that are distinct from, but highly correlated with, car weight) and the aggressivity effect of car weight. An increase in the proportion of lighter cars would lead to a small decrease in occupant fatalities in two-car accidents, a result of the reduced aggressiveness of relatively lighter cars. A countervailing effect of reduced crashworthiness in smaller cars would produce a small increase in deaths from other types of accidents in which the protective aspect of car size is the determining factor. These accidents include two-vehicle collisions with trucks and other heavier vehicles. The fatality rate changes from 1976-78 to 1986-88 for two-vehicle accidents conform to this pattern. The death rate for two-car collisions declined 22 percent, from 6.58 to 5.11.[10] Conversely, the death rate for all other multivehicle accidents increased about 11 percent, from 6.62 to 7.38. These two changes combined to form a small net improvement of 5 percent.

[10]The fatality rate for collisions with another car less than 10 years old declined even more sharply, from 5.54 to 3.40, a reduction of 39 percent.

This interpretation is not unprecedented. A number of highway safety researchers, including analysts from NHTSA, have attempted to predict the overall effect of downsizing on highway fatalities.[11] These researchers have seen the safety impact of light cars as a function both of the increased risk endured by the occupants of light cars and of the reduced danger posed to other roadway users by light cars in comparison with heavier ones.

Importantly, the work of these researchers is concerned with the effects of automobile size on the highway fatality rate or the total number of highway deaths, not just with the relationship between car size and fatality risk in the event of a collision. This means that their research captures the effects of variations in accident involvement rates that may exist among cars of different sizes, as well as the crashworthiness and aggressivity effects associated with automobile weight. While the conclusions of these researchers have not been identical, their estimates of the net effect on highway fatalities of increasing the proportion of light cars, whether positive or negative, are all close to zero. For example, estimates of the potential effect of doubling the proportion of subcompacts on the road in the late 1970's were clustered in a narrow band around zero change. Dreyer, Richter, and Zobel estimated a 2.3 percent decrease in deaths when considering only two-car accidents. Hedlund included single-car accidents and collisions with other vehicles (for example, car-truck crashes) along with two-car accidents, and estimated a total effect of 1.7 percent more deaths. Finally, Sparrow and Whitford added pedestrian and pedal-cyclist deaths to Hedlund's estimate, and predicted a 0.8 percent decrease in fatalities.[12]

The "humps" in the fatality rates that we have reported near the midpoints of the automobile weight distribution for both time periods are not new discoveries. Richter and Zobel (1982) reported the same finding, and Evans (1985c) found the same pattern for each of three separate driver age groups. As one possible explanation for this pattern, Evans and Wasielewski (1983) noted that cars of "intermediate mass" were particularly likely to be driven in a risky manner: following too closely behind the vehicles ahead of them. Another complementary possibility is that high performance cars, a group with very high occupant fatality

[11]For example, see Preston and O'Day, 1977; Dreyer, Richter, and Zobel, 1981; Richter and Zobel, 1982; Hedlund, 1983; Najjar, 1983; Sparrow and Whitford, 1984.

[12]Researchers have also estimated the effects of more dramatic changes in the automobile fleet. For example, Hedlund (1983) estimated that the total number of highway fatalities in 1979 would have been 2.7 percent larger if the fleet had been composed <u>entirely</u> of subcompact cars.

rates, may be found disproportionately in the middle weight categories. (For example, see Insurance Institute for Highway Safety, 1990b.)

Finally, one of the most important driver characteristics that can affect the distribution of fatalities across car weight categories is driver age. Drivers under 25, particularly males, are more prone to accidents than drivers older than 25. (See, for example, Williams and Carsten, 1989.) However, elderly drivers are less likely than younger drivers to survive a serious crash, because they are more susceptible to subsequent medical complications. (See, for example, Partyka and Boehly, 1989.) Since drivers of different age groups tend to drive cars of different sizes, it is possible to mistakenly attribute to automobile weight differences an effect on fatality rates that is actually the result of driver age differences. In general, it appears that age differences tend to artificially inflate the fatality rates of lighter cars—which, as our fatality data suggest, are more likely to be driven by younger drivers.[13] The driver age effect on the fatality rate of larger cars is less clear. If the age distribution of drivers in fatal crashes is similar to that of all drivers, large cars are less frequently driven by younger (riskier) drivers; they are more liable to be driven by elderly (frailer) drivers, although elderly drivers drive less. Without more accurate information on the miles traveled by each age group within each automotive weight category, it is impossible to quantify this effect precisely.

Implications for the Future

Our study examined the historical changes in fatality rates associated with the changes in automobile weight from the 1970's to the 1980's. We agree with the cautions expressed by NHTSA and other researchers about the danger of projecting quantitative relationships that applied in the past to future developments in the automotive fleet. However, it is clear from our analysis that lighter cars do not necessarily result in more total highway fatalities. All cars became safer during the period we examined, and the safety of lighter cars improved dramatically. Automotive manufacturers have succeeded in building cars that are both lighter and safer, partly as a result of new NHTSA regulations. The shift to lighter cars has reduced the proportion of heavy automobiles in service and thus reduced the danger that heavy automobiles pose to other roadway users. In coming years, automobile occupant safety may be enhanced to the extent that future automobile weight changes result in decreasing weight variations between cars.

[13]See appendix III.

Methodology

We asked NHTSA to make available to us two data sets that it maintains for highway safety researchers. One data set is from the Fatal Accident Reporting System (FARS); this includes information on persons and vehicles involved in roadway incidents since 1975 that resulted in at least one fatality. The second data set is the R.L. Polk and Company's National Vehicle Population Profile. The Polk data set has information on the types, numbers, and weights of vehicles registered each year. At the time of our request, NHTSA's consolidated vehicle registration data base ended at 1988, so our analysis is restricted to the years 1975 through 1988. We used these data for several purposes:

1. We developed a profile of changes in the distribution of automobile weights for those years.

2. We developed a profile of changes in the automobile occupant fatality rate for those same years. Fatality rate is defined here as the number of persons killed in a given category of passenger cars for every 100,000 of those vehicles registered per year. For the fatality rates, deaths and automobiles with missing car-weight information were prorated among the automobile-weight and accident-type categories in order to facilitate year-to-year comparisons.

Partyka (1990) reported a mismatch in the automobile weight figures from the FARS and Polk data sets, with the Polk weight measures about 140 pounds heavier on average than the FARS weight measurements for the same cars. Since our fatality rate measures consist of a numerator from FARS (number of deaths) and a denominator from the Polk data set (number of registrations), we needed to adjust for this disparity. We reduced the degree of mismatch by adding a number of pounds to the FARS weight measurement for each car. The number of pounds added for each cars was based on a linear regression model; thus, the number of pounds added was slightly greater for heavier cars than for light cars.

3. We constructed two comparable data sets of new cars that were part of the automobile fleet a decade apart, in 1976-78 and 1986-88. Using these data sets, we conducted an analysis of the fatality rates for different weight categories of passenger cars and for different types of accident.

For these data sets, we defined automobiles as vehicles with the FARS body type codes 1 through 9. These codes are (1) convertible; (2) 2-door sedan, hardtop, coupe; (3) 2-door/3-door hatchback; (4) 4-door sedan, hardtop; (5) 4-door/5-door hatchback; (6) station wagon; (7) hatchback, number of doors unknown; (8) other automobile; and (9) unknown automobile type.

We selected cars that were 1 and 2 years old for each calendar year in the data set. More specifically, the 1976-78 data set tracked the on-the-road experience of model year 1974 and 1975 cars in calendar year 1976, model year 1975 and 1976 cars in calendar year 1977, and model year 1976 and 1977 cars in calendar year 1978. The 1986-88 data set followed the same pattern for the next decade. A case in these data sets is one automobile registered for 1 year. The 1976-78 data set contained approximately 52,987,000 annual auto registrations, while the 1986-88 data set consisted of approximately 62,963,000 annual auto registrations.

The data sets were restricted to 1- and 2-year-old cars in order to reduce the confounding effects of major shifts in automobile design, poor maintenance, and differential longevity, as well as the decrease in annual miles of travel associated with increasing automobile age. (See COMSIS Corporation, 1986, for estimates of the variability of annual mileage traveled as a function of automobile age.) Thus, we believe that looking at the on-the-road experiences only of relatively new cars gave us a clearer picture of the effects of automobile weight than if we had followed the standard practice and included all registered cars in the data sets. In addition, the cars in our 1986-88 data set were a much closer approximation of automobiles entering the fleet today than would have been the case if we had included registered cars of all ages for those years.

We were unable to include current model year cars because a limitation of the registration data would have led us to underestimate severely the number of those cars in service. This situation occurs because the Polk registration data set is a "snapshot" of the national registration figures taken each year on July 1, and about one third of the cars for each model year are put in service after July 1. For example, we found that there were approximately 7.0 million model year 1987 cars registered on July 1, 1987, but about 10.4 million model year 1987 cars registered on July 1, 1988.

We conducted our analysis in accordance with generally accepted government auditing standards during the period April to August 1991.

Young Drivers and Automobile Fatality Rates

Driver age is a critical factor in the fatality rates reported for different categories of automobiles. Young drivers are exceptionally likely to be involved in fatal accidents. For instance, in 1988, drivers aged 16 to 24 were 17 percent of all those with driver's licenses, but they accounted for about 30 percent of the drivers involved in fatal accidents. In contrast, about 70 percent of all driver's license holders were aged 25 to 64, but they made up only 59 percent of those involved in fatal accidents; drivers aged 65 and older had the lowest rate of fatal accident involvement by this measure—they were 12 percent of licensed drivers, but only 9 percent of those involved in fatal accidents (Bureau of the Census, 1990). Thus, to the extent that particular groups of cars are driven disproportionately by young drivers, the reported fatality rates may overstate the danger of those cars, and conversely, the fatality rates for categories of cars with unusually low proportions of young drivers are likely to understate their true danger.

While we do not know how driver age is distributed across automobile weight categories in the driving population (that is, among drivers who are not involved in fatal accidents), we do have information about the drivers involved in fatal accidents. (These are individuals who were driving a car that was involved in an accident with at least one fatality, but who were not necessarily killed, or even injured, in that accident.)

As shown in table III.1, some modifications to the age distribution of drivers across automobile weight categories occurred between 1976-78 and 1986-88. Nevertheless, young drivers still tended to be concentrated in the lighter weight groupings. For both time periods, the heaviest cars involved in fatal accidents were much less likely to have drivers aged 16 to 24 than were the lightest cars, and the percentage of cars with young drivers generally declined with each increasing weight category. In 1986-88, the percentage of young drivers in the lightest car category (2,000 pounds or less) was approximately four times greater than in the two heaviest car categories (3,501 to 4,000 and 4,001 to 4,500 pounds). To the extent that (1) the drivers in fatal accidents are representative of all drivers and (2) drivers aged 16 to 24 are more likely to be involved in fatal accidents, the fatality rates for cars in the lighter car categories in 1986-88 are overstated relative to the fatality rates for those in the heavier weight categories.

Table III.1: Percentages of Drivers Aged 16 to 24 Involved in Fatal Accidents, 1976-78 and 1986-88[a]

Automobile weight category[b]	1976-78	1986-88	Percent change
2,000 or less	46.6	43.4	−7
2,001 to 2,500	50.7	39.0	−23
2,501 to 3,000	49.3	34.7	−30
3,001 to 3,500	41.4	27.3	−34
3,501 to 4,000	39.7	11.0	−72
4,001 to 4,500	23.4	11.7	−50
4,501 to 5,000	15.7	[c]	[c]
5,001 to 5,500	13.7	[c]	[c]
Average	37.6	33.3	−11

[a]Entries are for each automobile weight category. Percentages were computed from cars involved in one- and two-car accidents.

[b]In pounds.

[c]In 1986-88, this weight category contained no cars.

In view of young drivers' continuing preference for lighter cars, it is unlikely that the dramatic decrease in light car fatality rates between 1976-78 and 1986-88 is attributable to a shift by young drivers to heavier cars. However, the steep decline in the proportion of young drivers of cars in the 3,501 to 4,000 pound category may to some extent explain the decline in fatality rates for that group.

NHTSA's Estimate of Fatalities Related to Downsizing

How Many Fatalities?

In a recent summary of its research, NHTSA reported that "nearly 2,000" additional fatalities annually could be attributed to the downsizing of cars since 1975. This estimate actually substantially understates NHTSA's view of the magnitude of the downsizing effect. In that same paper, NHTSA noted that there are five principal categories of crashes involving automobiles that together account for about 23,500 occupant fatalities yearly. These are (1) rollover accidents, 4,500 fatalities; (2) one-car nonrollover accidents, 7,000 fatalities; (3) collisions between two passenger cars, 5,000 fatalities; (4) collisions between a passenger car and a light truck, van, or utility vehicle, 4,500 fatalities; and (5) collisions between cars and large trucks, 2,500 fatalities (NHTSA, 1991b, p. 5). The estimate of "nearly 2,000" fatalities considers only projected fatalities in the first two crash categories—that is, one-car accidents. Thus, NHTSA projects 1,340 more fatalities in rollover accidents and 633 more deaths in one-car nonrollovers, for a total of 1,973—that is, "nearly 2,000" (NHTSA, 1991b, pp. 7, 10).

NHTSA's research involving collisions between two cars, and collisions between automobiles and large trucks, used a different dependent variable—serious or fatal injuries—in place of fatalities measured separately. For this reason, the results of those analyses were not included in the estimate of "nearly 2,000" additional fatalities. However, for those types of accidents, NHTSA attributes thousands of additional serious injuries annually to the effects of automobile downsizing. Since it is unlikely that any factor would lead to so many serious injuries without causing additional fatalities, we formulated an ad hoc projection of fatalities by applying to the results of those studies estimates of the ratio of the number of fatalities to the number of serious injuries. We derived one estimate of this ratio from NHTSA's reports that there were about 342,000 seriously or fatally injured automobile occupants in 1989 (NHTSA, 1990, p. 78), and that there were 25,046 automobile occupant fatalities in that year (NHTSA, 1991c, pp. 1-8). According to these figures, the number of fatalities is about 7.3 percent of the number of fatal and serious injuries combined (25,046/342,000). However, another NHTSA study reported a much larger estimate of that percentage. (See Partyka and Boehly, 1989, p. 30.) After analyzing tow-away accidents for the years 1978 through 1987, Partyka and Boehly reported that the number of driver fatalities was about 21.9 percent of the total number of serious and fatal injuries to drivers.

In two-car crashes, NHTSA estimated that downsizing accounted for between 5,300 and 16,000 additional serious injuries annually (NHTSA, 1991b, pp. 11-12). Averaging those two estimates (10,650) and multiplying by .073 yields 777 deaths; multiplying 10,650 by .219 yields 2,332 fatalities. Similarly, in collisions between cars and large trucks, NHTSA estimated that an additional 1,800 automobile drivers are seriously or fatally injured each year (NHTSA, 1991b, p. 13). Multiplying this figure by .073 yields an estimate of 131 fatalities; multiplying by .219 yields 394 more fatalities.

The remaining crash category is collisions between cars and light trucks, vans, and utility vehicles. NHTSA has not conducted a separate analysis of these collisions because reasonably accurate and complete data about the weight of light trucks are not available. (See NHTSA, 1991b, p. 5.) For our fatality estimates in these accidents, we make the conservative assumption that the percentage of all automobile occupant deaths in these collisions due to downsizing is the same as the percentage of all deaths due to collisions with large trucks. Using the numbers from the previous paragraph, this yields 5.2 percent as a low estimate (131 out of 2,500 fatalities) and 15.8 percent as a high estimate (394 out of 2,500 fatalities). Applying these two percentages to NHTSA's figure of 4,500 annual auto occupant deaths in collisions with light trucks, vans, and utility vehicles yields 234 (4,500 x .052) and 711 fatalities (4,500 x .158), respectively, due to downsizing.

Considering all of the components of this line of research, our low estimate of the number of deaths that NHTSA actually attributed to downsizing is 3,115 (1,340 + 633 + 777 + 131 + 234), or about 13 percent of annual automobile occupant fatalities (3,115/23,500). Our high estimate of that figure is 5,410 (1,340 + 633 + 2,332 + 394 + 711), or 23 percent of annual deaths.

It is important to emphasize that this estimate of between 3,115 and 5,410 additional deaths annually due to automobile downsizing since the mid-1970's (roughly between 13 and 23 percent of all automobile occupant fatalities) represents our calculation of what NHTSA's projection of this effect would have been had it included all categories of accidents. This is not our estimate of the effect of downsizing on automobile fatalities; as appendix I shows, our conclusion is that automobile weight reductions have had virtually no effect on total highway fatalities. Further, the estimate that between 13 and 23 percent of fatalities are attributable to downsizing is much higher than some earlier estimates, which projected a total net effect of automobile weight reductions on highway fatalities of at most only a few percentage points. (See, for example, Richter and Zobel, 1982; Hedlund, 1983.)

Implications of the Reduced Range of Automobile Weights for NHTSA's Estimates

In appendix I, we reported that the range of automobile weights was substantially smaller in 1988 than in 1975 and that larger cars were downsized more than small cars during that period. These findings mean that NHTSA's projections of the effects of downsizing on injuries in two-car accidents are overstated. (See NHTSA, 1991b, pp. 11-12.) NHTSA estimated that a reduction in average auto weight of 1,000 pounds has led to an increase in serious and fatal injuries in two-car accidents of between 4.3 percent and 14.3 percent. That estimate was based on differences in the average weight of cars on the road, without consideration of the shrinking variability of automobile weights, and with the assumption that all car weights declined by an equal proportion. NHTSA is aware of the latter difficulty: "If the assumption that all car weights decreased by equal proportions is replaced by another scenario of downsizing, the quantitative estimate of the effect of weight reduction would likely be somewhat different, although its direction would be the same" (NHTSA, 1991b, p. 11).

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