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Estimating Alcohol Involvement in Fatal Crashes in Light of Increases in Restraint Use

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16. Abstract

In 1994, 40.8 percent of traffic fatalities occurred in crashes involving alcohol. Reducing the incidence of alcohol involvement in traffic crashes is one of the National Highway Traffic Safety Administrations's highest priority programs. Another of NHTSA's highest priorities is increasing the use of occupant protection systems - safety belts, child safety seats, and motorcycle helmets. While these two safety programs complement one another, it is worth investigating their interaction with regard to measuring and assessing program progress over time. The use of occupant restraints saves lives, and a strong inverse relationship between restraint use and alcohol involvement has been observed in the fatal crash data. The primary database used to study the role of alcohol involvement in serious crashes is the Fatal Accident Reporting System (FARS), which shows that drivers in fatal crashes who have been drinking are less likely to be restrained than are sober drivers. In addition, the increase in restraint use is greater among non-drinking drivers.

As restraint use increases, more lives are saved. Since restraint use is higher among sober drivers, the true trend in alcohol involvement in fatal crashes may be masked by the differential increases in occupant restraint use. Those that are most likely to use restraints are less likely to be involved in an alcohol-related crash. Nonalcohol-involved occupants will be "saved" at a higher rate than those in alcohol-related crashes, are less likely to become a crash fatality, and therefore will not appear in the FARS database. As these restrained, nonalcohol-involved occupants are removed from the pool of fatalities, the percentage of alcohol involved fatalities becomes comparably larger.

To compensate for the disproportionate rates at which occupants at different levels of alcohol involvement are being saved by restraints, the percentage of fatalities at each BAC level have been recalculated, taking into account restraint effectiveness. From this is derived a more representative estimate of alcohol involvement, the rate of alcohol involvement in potentially fatal crashes, or the potential rate of alcohol involvement. Potentially fatal crashes are those crashes which would have been fatal to an unrestrained occupant. In determining potential fatalities, specific restraint type (manual or automatic safety belt, child seat, motorcycle helmet) as well as vehicle type and seating position were accounted for. In 1994, the actual rate of alcohol involvement for fatalities was 40.8 percent, while the potential rate of alcohol involvement was 38.1 percent. As the rates of restraint use increases between alcohol- and nonalcohol-involved fatalities, this difference will continue to grow.

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Estimating Alcohol Involvement in Fatal Crashes in Light of Increases in Restraint Use

National Center for Statistics and Analysis
July, 1996

Background

Alcohol plays a major role in the incidence and severity of traffic crashes. As such, alcohol is one of the National Highway Traffic Safety Administration's (NHTSA) highest priority programs in achieving its mission of reducing the mortality and morbidity that result from traffic crashes. The primary database used to study the role of alcohol involvement in serious crashes is the Fatality Analysis Reporting System (FARS). FARS is a nationwide census of fatal traffic crashes occurring on public roads in which at least one person died within 30 days of the crash. Information from police accident reports (PARs), supplemented by driver licensing records, coroner's reports, and emergency medical services reports, is used to create data files with information on the crash, vehicles, and persons involved.

FARS contains two pieces of information on the presence of alcohol involvement among drivers and pedestrians (including pedalcyclists): police-reported alcohol involvement and actual Blood Alcohol Concentration (BAC) test results. In addition, drug and alcohol violations charged to drivers are recorded. The most reliable information is the actual BAC test result. In the absence of a known BAC, a positive indication of alcohol involvement on the police report is a good barometer.

For a number of reasons, BAC test results are not available for all drivers and pedestrians involved in fatal crashes. Some states have laws or policies for mandatory testing of traffic fatalities, yielding high rates of known BACs. In 1995, known BAC test results were available for 68 percent of all driver fatalities.

Unfortunately, the situation is quite different for surviving drivers. In 1995, known BAC test results were available for 24 percent of all surviving drivers in fatal crashes. Evidence suggests that those persons who are tested for BAC are more likely to have been drinking than those who were not tested. This is especially true for surviving drivers in fatal crashes.

To improve the accuracy and usefulness of the available data, a method of estimating alcohol involvement in fatal crashes was developed in 1986 [1]. Using statistical models, variables associated with alcohol involvement were utilized to estimate, for each driver and pedestrian with unknown BAC in FARS, probabilities for each of three BAC groups: 0.00, from 0.01 to 0.09, and 0.10 and greater. The three groups correspond to no alcohol (also referred to as "sober"), a moderate amount of alcohol (0.01 to 0.09), and an intoxicating level of alcohol

(0.10 and above, as is the legal definition in most states). The latter two groups are often combined and referred to as the "drinking" or "alcohol-involved" group.

Unless otherwise noted as being based on only known BAC test results, all estimates of alcohol involvement presented in this paper are based upon the FARS imputed alcohol distributions; that is, the combination of known and estimated BACs. Alcohol involvement estimates are available for FARS data from as early as 1982, and enable the use of data for which alcohol presence would otherwise be classified as "unknown". Examination of the BAC groups over these years shows that the presence of alcohol has decreased [2]. For example, in 1982, 46.3 percent of all fatalities involved at least one driver or pedestrian with BAC at or above 0.10. By 1995, this had figure declined to 32.5 percent. Looking at drivers involved in fatal crashes, the percentage of those intoxicated decreased from 30.0 to 19.3 during the same time period. The percentages of fatalities by crash BAC as estimated from FARS are shown in Exhibit 1 [2].

Exhibit 1
Traffic Fatalities by Crash BAC
FARS 1982-1994

Year	**0.00**	**0.01-0.09**	**0.10+**
1982	42.7	10.9	46.3
1983	44.5	10.5	45.0
1984	46.3	10.8	42.9
1985	48.2	10.5	41.3
1986	47.8	11.1	41.1
1987	49.0	11.0	39.9
1988	49.8	10.4	39.8
1989	50.8	10.0	39.2
1990	50.5	9.9	39.6
1991	52.1	9.5	38.4
1992	54.5	9.2	36.3
1993	56.5	8.7	34.9
1994	59.2	8.6	32.2
1995	58.7	8.9	32.4

Another of NHTSA's highest priority programs aims to increase the use of occupant protection systems (safety belts, child safety seats, and motorcycle helmets). The occupant protection program has made great strides over the last decade, with large increases in belt, child safety seat, and helmet use. A number of years ago, the alcohol countermeasure and occupant protection programs were linked together, with the motto of, "Buckle up, it's the best defense against the drunk driver."

While these two high-priority safety programs complement one another, it is worth investigating their interaction with regard to measuring and assessing program progress over time.

The FARS alcohol data can be subdivided in various ways to determine, for example, the rate of alcohol involvement by age, sex, type of vehicle, or any of the many variables present in FARS. One association that yields a striking pattern is that between alcohol involvement and safety belt use in fatal crashes. In 1995, 45.9 percent of sober fatally injured drivers of all types of vehicles were reported to have been restrained (by belts or, for motorcycle drivers, helmets), while the same was true for only 20.2 percent of intoxicated drivers. Restraint use among surviving drivers was higher for both the sober and intoxicated groups: 77.2 percent of sober drivers and 40.9 percent of intoxicated drivers reportedly used restraints. Intoxicated drivers in fatal crashes were about half as likely as sober drivers to have been restrained at the time of the fatal crash.

The trend of passenger vehicle driver restraint use for the different alcohol involvement groups, shown in Exhibits 2A and 2B, gives additional information. Both parts of Exhibit 2 are based only on known reported restraint use, since unknowns are not imputed in FARS for this variable.

Exhibit 2A
Passenger Vehicle Driver Restraint Use Rates
Restraint Use Rate as Reported in FARS
-- BAC Category, Imputed FARS -- Survey

	0.00	**0.01-0.09**	**0.10+**	Survey
1982	6	3	2	11
1983	7	4	2	14
1984	10	6	3	14
1985	22	13	6	21
1986	35	22	11	37
1987	43	26	13	42
1988	48	28	14	45
1989	50	29	15	47
1990	54	32	16	49
1991	57	36	18	51
1992	60	37	20	62
1993	62	40	22	66
1994	65	41	29	67
1995	66	44	26	

Exhibit 2B
Passenger Vehicle Driver Restraint Use Rates
Restraint Use Rate as Reported in FARS
-- BAC Category, Known BAC Cases Only--

	0.00	**0.01-0.09**	**0.10+**
1982	5	4	2
1983	6	4	2
1984	9	5	2
1985	17	10	5
1986	26	16	9
1987	31	20	11
1988	35	22	12
1989	37	23	12
1990	40	26	14
1991	43	29	16
1992	45	31	18
1993	49	35	20
1994	53	36	23
1995	52	38	21

As can be seen in Exhibit 2A, from 1982 to 1995 reported restraint use increased among nondrinking drivers from 6 percent to 66 percent. The lower level alcohol group increased restraint use from 3 to 44 percent, while the intoxicated group went from 2 to 26 percent. The nondrinking group was consistently reported as having a higher rate of restraint use than were the drinking groups. Overall, driver restraint use increased from 4 percent to 57 percent.

Looking at these data as the reduction in "problem behavior" (that is, driving around unrestrained, which is analogous to the manner in which alcohol involvement is considered), lack of restraint use declined among sober drivers by 64 percent (from 94 percent in 1982 to 34 percent in 1995). This behavior declined by 42 percent among the lower level alcohol drivers (from 97 percent in 1982 to 56 percent in 1995) and by 24 percent among the intoxicated drivers (from 98 percent in 1982 to 74 percent in 1995). Much greater progress has been made in increasing restraint use among sober drivers than among drinking drivers, as evidenced by the FARS data.

Since the BAC imputation model includes driver restraint use as a predictor of alcohol involvement, it is worth investigating whether the same trend exists only for those cases with known BAC test results, to ensure that the imputation model is not the source of this inverse alcohol-restraint use relationship. Exhibit 2B displays the same information as Exhibit 2A, **but only for those drivers with known BAC test results**. The same pattern of increasing restraint use across BAC categories is present, corroborating what was observed in the imputed data. The same trend also can be seen for fatally injured drivers (not shown in the table), but at lesser levels of restraint use. As previously mentioned, the percentage of known BAC results is much higher for fatally injured drivers than those that survived, since the test is often performed in conjunction with an autopsy. The results of this are reflected in the differences between Exhibits 2A and 2B. Since the known BAC group contains a larger proportion of fatally injured drivers, the restraint use tends to be lower in all BAC categories.

The Survey column in Exhibit 2A reports two types of data. From 1992 through 1994, NHTSA's estimate of the national belt use rate was based on individual state surveys. To calculate the national safety belt use rate from individual state use rates, each state's most recent rate is weighted by that state's proportion of the total U.S. population.

A project sponsored by NHTSA through 1991 looked at restraint use in 19 cities in the United States, and included information covering various types of restraint systems [3]. The cities were originally selected to represent various geographical regions of the country, covering a variety of demographic and driving conditions. The sites used for studies of passenger vehicle restraint use were primary road intersections and freeway exits.

While this is not a true probability-based survey of belt use in the United States, the historical consistency with which observations were conducted does provide an index that can be used to monitor trends. Within the limitations of this survey, Exhibit 2 demonstrates that restraint use in the general population has increased over the past several years.

Reported belt use in FARS is subject to some uncertainty, since in many cases the police obtain this information from the vehicle occupants themselves. There can be motivation for occupants of a crash-involved vehicle to misrepresent their restraint use. In states with mandatory restraint use laws, a fine could result from having been unrestrained. Also, insurance companies offer incentives in the form of lower premiums to use restraints. For example, the Michigan Department of State Police found that the use rate gathered from police accident reports was 84 percent, while direct observation studies reported only a 50 percent use rate [4].

These biases can be minimized by limiting data to fatalities, since their reported restraint use should be less prone to falsification and therefore more reliable. The present analysis looks only at fatalities, but some bias may still exist in reported restraint use.

The use of occupant restraints saves lives, and a strong inverse relationship between restraint use and alcohol involvement has been observed in the fatal crash data. There are clear implications for measuring progress in the alcohol countermeasure and restraint use programs.

Potential Fatalities

As restraint use increases, more lives are saved. The previous discussion demonstrated a much greater increase in restraint use among sober drivers than among drinking drivers, based on data from FARS. From this one can surmise that the true trend in alcohol involvement in fatal crashes may be masked by these differential increases in occupant restraint use. Those that are most likely to use restraints are less likely to be involved in an alcohol-related fatal crash. Nonalcohol-involved occupants will be "saved" at a higher rate than those in alcohol-related crashes, are less likely to become a fatality in a motor vehicle crash, and therefore not appear as a fatality in FARS. As these restrained, nonalcohol-involved occupants are removed from the pool of fatalities, the percentage of alcohol-involved fatalities becomes comparably larger.

Assessments of program progress should always attempt to isolate the effect of program activities (alcohol countermeasures) from the effect of other factors (e.g., changes in restraint use) so as to avoid the confounding influence of their interaction. In order to compensate for the disproportionate rates at which occupants in the different BAC groups are being saved by restraints, the percentage of fatalities at each BAC level have been recalculated, taking into account restraint effectiveness. Using this method, those that were saved by restraints, both alcohol-involved and nonalcohol-involved, would be accounted for in the calculations, and a more representative estimate of alcohol involvement could be determined. This new rate, the **rate of alcohol involvement in potentially fatal crashes** (hereinafter referred to as the **potential rate of alcohol involvement**), should be more representative of the true trend in alcohol involvement based on a more standardized, constant population which is not implicitly dependent on restraint use. **Potentially fatal crashes** are those crashes which would be fatal to an unrestrained occupant; persons who would be fatally injured in a potentially fatal crash are referred to as **potential fatalities**. Persons who were fatally injured in actual fatal crashes are referred to as **actual fatalities**. Even though the percentage of crashes involving alcohol has declined, the decrease is even more dramatic when lives saved by restraints are also taken into account.

Data

The number of fatalities for each year, from 1982 to 1995, was obtained from FARS, separately by vehicle type (passenger car, light truck/van/utility, motorcycle, medium/heavy truck, other vehicle, or nonoccupant), seating position, and reported use and type of restraint system. Fatally injured infants (age less than one year) and toddlers (ages one through 4) who were occupants of cars and trucks were separated from older occupants of these vehicles. Effectiveness estimates for child safety seats differ from other types of restraints, as does the effectiveness of adult belts used by such young passengers.

The imputed FARS data were used to calculate the percentage of fatalities within each of the crash BAC groups. The crash BAC is obtained from all person-level BACs in a single crash [1]. Specifically, it is the joint probability distribution of all drivers and nonoccupants (i.e., active participants) involved in a crash. The alcohol level of passengers (i.e., nondriving occupants) is not considered to be a factor in a crash and therefore is not included in the calculation.

A crash is considered to be at 0.00 BAC if all involved active participants had a BAC of 0.00. A crash is considered to be between 0.01 and 0.09 BAC if at least one active participant had a BAC above zero, but none had a BAC as high as 0.10. A crash is considered to have a BAC of 0.10 or greater if at least one active participant had a BAC of 0.10 or greater. The crash BAC may be considered to be the highest BAC of any active participant. All fatalities in a single crash share a common crash BAC.

The number of potential fatalities depends on the number of occupants reported to be using restraints as well as the effectiveness of the type of restraint used. While the alcohol level of passengers is not a factor in the alcohol level of the crash, their presence and restraint use habits clearly influence the fatality count. The effectiveness of a restraint system is defined as the percentage reduction in the risk of fatal injury for restrained occupants as compared to unrestrained occupants. Each restraint type has a different effectiveness measure, which also varies by the seating location and type of vehicle [5,6,7,8,9,10].

For example, manual lap belts have been found to be 35 percent effective for occupants in the front center seat of passenger cars, 50 percent effective for those in the front center seat of light trucks, vans and utility vehicles, and 32 percent effective for rear-seat occupants regardless of vehicle. The effectiveness estimates used in this analysis are presented in Exhibit 3. Effectiveness is most often presented as a range of values, and the midpoint of the range is used for calculations. Only the midpoints are presented here, since these were the values used to determine the number of potential fatalities.

Exhibit 3
Restraint Effectiveness Estimates
for Preventing Fatalities

Seat Position/ Restraint Type	**Passenger Cars**	**Light Trucks**
Front Outboard/Air bag alone	0.100	0.100
Front Outboard/Manual 3-pt.	0.450	0.600
Front Outboard/Air bag + Manual 3-pt.	0.505	0.640
Front Outboard/Automatic 2-/3-pt.	0.425	0.567
Front Center/Manual Lap Belt	0.350	0.500
Rear/Lap Belt	0.320	0.320
Rear/3-pt.	0.410	0.410
Ages 0 - 4:	**Infants**	**Toddlers**
Child Restraint	0.690	0.470
Adult Belt (any type)	0.360	0.360
Other Vehicles:		
Motorcycle Helmets	0.290	
Medium/Heavy Truck Manual 3-pt.	0.260	

An effectiveness estimate of 26 percent was used for restraints in medium and heavy trucks. Although this value has been calculated only for heavy trucks [9], the crash experience is similar for medium trucks, both experiencing an approximate 15 percent rollover rate, and so belt effectiveness should be comparable.

Other estimates of safety belt effectiveness have been developed, but were not used in the current analysis. For example, NHTSA's recently released evaluation of the effectiveness of occupant protection [11] estimated the fatality-reducing effectiveness of air bags and each type of automatic belt system. The method used in the report, however, examined *actual* fatality reductions, taking into account use rates. That is, effectiveness estimates for each system were *as used*, rather than *when used*. The former approach was deemed most appropriate to address the effectiveness of automatic systems since one of the major objectives of requiring automatic occupant protection was to increase system use. Thus, differences in use between manual and automatic systems become part of the effectiveness determination. The present method required *when used* estimates of effectiveness to calculate lives saved at the person level, which were then incorporated into the revised BAC calculations.

The FARS analysis file contains the first ten digits of the vehicle identification number (VIN), a seventeen digit code unique to each vehicle, from which restraint type can be determined. The VIN was used to ascertain the type of restraint system available to front outboard occupants in passenger cars. In addition, a few light trucks, vans, and utility vehicles have driver air bags and/or automatic belts. These were identified using the VINA_MOD and SER_TR codes, which are derived from the VIN. All other vehicles were classified as having only manual belts available.

Only manual lap belts are available in the front center seat. A few vehicles have three point manual restraints in the rear outboard seating positions, with most occupants in rear seats having only a manual lap belt available. Unless the FARS file specifically indicated a rear outboard occupant was wearing a lap and shoulder belt, the lap belt alone was assumed.

Analysis

Since sober drivers appear more likely than drinking drivers to use restraints, they are consequently less likely to be killed, even when involved in a potentially fatal crash. The goal of the present study was to determine, for potential fatalities in motor vehicle crashes, the percentage involving alcohol. Once this was done, the trend in the potential rate of alcohol involvement could be examined, and compared to alcohol involvement in fatal crashes as recorded in FARS.

Exhibit 4 presents the data from the 1995 FARS file (i.e., the imputed alcohol file), with those vehicle occupants having unknown restraint use already distributed to the various categories of restraint use using proportional allocation within appropriate groups. The data are disaggregated by vehicle type, occupant seating position, available restraint system, reported restraint use, and BAC group (based on the imputed accident-level BAC distributions). Vehicle occupants under age five constitute a separate group. Total fatalities, as well as the number at each BAC level, are presented. The percentages of total fatalities at each BAC level, for the data as they appear in the 1995 FARS, are presented in the last row of Exhibit 4.

Exhibit 4

1995 Motor Vehicle Fatalities, by Vehicle Type, Seating Position, Restraint Type and Reported Use, and BAC, with Unknown Restraint Use Distributed

Vehicle Type	Seating Position	Restraint Type	Restraint Use	Total	BAC 0.00	BAC 0.01 -0.09	BAC 0.10+
Pass Car	Front out	Manual	Belt	3,826	2,826	296	707
Pass Car	Front out	Manual	Bag only	1,624	868	165	591
Pass Car	Front out	Manual	Bag+Belt	1,534	1,102	118	314
Pass Car	Front out	Manual	Unrestr	7,774	4,016	713	3,045
Pass Car	Front out	Automatic	Belt	2,645	1,942	204	499
Pass Car	Front out	Automatic	Bag only	148	76	16	56
Pass Car	Front out	Automatic	Bag+Belt	160	125	7	28
Pass Car	Front out	Automatic	Unrestr	1,848	1,002	186	660
Pass Car	Front out	Unk	Belt	138	102	13	23
Pass Car	Front out	Unk	Bag only	0	0	0	0
Pass Car	Front out	Unk	Bag+Belt	0	0	0	0
Pass Car	Front out	Unk	Unrestr	162	84	10	68
Pass Car	Front Ctr	Lap only	Restrain	10	4	1	5
Pass Car	Front Ctr	Lap only	Unrestr	65	39	9	17
Pass Car	Front Unk		Restrain	0	0	0	0
Pass Car	Front Unk		Unrestr	16	11	1	4
Pass Car	Rear	Lap only	Restrain	197	158	18	21
Pass Car	Rear	Lap only	Unrestr	1,386	840	191	355
Pass Car	Rear	Lap+Shld	Restrain	150	108	20	22
Pass Car	Other		Restrain	0	0	0	0
Pass Car	Other		Unrestr	71	45	9	17
Pass Car	Unk		Restrain	18	15	1	2
Pass Car	Unk		Unrestr	166	79	38	49
LTV/Util	Front out	Manual	Belt	1,409	978	93	338
LTV/Util	Front out	Manual	Bag only	205	111	13	81
LTV/Util	Front out	Manual	Bag+Belt	133	112	6	15
LTV/Util	Front out	Manual	Unrestr	4,744	2,162	402	2,180
LTV/Util	Front out	Automatic	Belt	2	2	0	0
LTV/Util	Front out	Automatic	Bag only	1	0	0	1
LTV/Util	Front out	Automatic	Bag+Belt	1	1	0	0
LTV/Util	Front out	Automatic	Unrestr	4	2	0	2
LTV/Util	Front out	Unknown	Belt	414	287	41	86
LTV/Util	Front out	Unknown	Bag only	0	0	0	0
LTV/Util	Front out	Unknown	Bag+Belt	0	0	0	0
LTV/Util	Front out	Unknown	Unrestr	1,219	555	93	571
LTV/Util	Front Ctr	Lap only	Restrain	15	12	1	2
LTV/Util	Front Ctr	Lap only	Unrestr	157	67	26	64

(continued)

Exhibit 4

1995 Motor Vehicle Fatalities,
by Vehicle Type, Seating Position,
Restraint Type and Reported Use, and BAC,
with Unknown Restraint Use Distributed

(continued)

Vehicle Type	Seating Position	Restraint Type	Restraint Use	Total	0.00	BAC 0.01 -0.09	0.10+
LTV/Util	Front Unk		Restrain	1	1	0	0
LTV/Util	Front Unk		Unrestr	28	11	3	14
LTV/Util	Rear	Lap only	Restrain	48	39	3	6
LTV/Util	Rear	Lap only	Unrestr	416	283	43	90
LTV/Util	Rear	Lap+Shld	Restrain	37	29	1	7
LTV/Util	Other		Restrain	11	10	0	1
LTV/Util	Other		Unrestr	371	250	38	83
LTV/Util	Unk		Restrain	4	3	1	0
LTV/Util	Unk		Unrestr	121	63	12	46
MC	Driver	Helmet	Restrain	1,143	660	146	337
MC	Driver	Helmet	Unrestr	870	438	108	324
MC	Passenger	Helmet	Restrain	92	52	12	28
MC	Passenger	Helmet	Unrestr	116	46	21	49
Med/Hvy Truck		Lap only	Restrain	151	139	5	7
Med/Hvy Truck		Lap only	Unrestr	490	432	33	25
Other vehs				515	334	36	145
Infant		Belt		2	2	0	0
Infant		Car Seat		52	41	4	7
Infant		Unrestr		98	67	7	24
Toddler		Belt		81	62	5	14
Toddler		Car Seat		131	107	9	15
Toddler		Unrestr		251	189	25	37
Non occupants				6,524	3,534	512	2,478
Total				**41,795**	**24,523**	**3,712**	**13,560**
Percentages					**58.7%**	**8.9%**	**32.4%**

[Note: Columns may not add due to rounding]

For vehicle occupants, the next step was to distribute those with unknown seating position and/or restraint type. (Nonoccupants and occupants of "other" vehicles were not classified by seat position or restraint type. The "other" group consists of buses, snowmobiles, nontruck farm and construction equipment, all-terrain vehicles and miscellaneous other vehicles unlikely to have restraint systems.) These counts were adjusted for vehicle occupants according to the type of restraint used. For these, the number of fatally injured occupants was inflated according to the effectiveness of the restraint system, in order to obtain the number of those potentially involved. The actual number of fatalities could then be subtracted from the adjusted value to determine the number of lives saved by the restraint system.

To obtain the number of potential fatalities, the number of fatalities reported to have been restrained was divided by 1 minus the effectiveness of the available restraint. For example, using front center seat occupants of passenger cars, there was a total of 10 restrained fatalities in 1995. Manual belts in this seating position have an effectiveness of 35 percent (0.35) with respect to fatality reduction. Dividing the number of fatalities by (1 - 0.35), or 0.65, yielded 15 potential fatalities. The number of lives saved, then, by front center seat manual belts in passenger cars in 1995 would be 15 minus 10, or 5 lives saved.

The calculations were performed on the numbers from Exhibit 4 after occupants with unknown seating position and restraint type had been distributed. Exhibit 5 presents the fatality counts, again both total and classified by BAC level, for each seating position/restraint group for 1995, with all unknowns having been distributed.

Exhibit 5
1995 Potential Motor Vehicle Fatalities,
by Vehicle Type, Seating Position,
Restraint type and Reported Use, and BAC,
with Unknown Seating Position and Restraint Type Distributed

						BAC	
Vehicle Type	**Seat**	**Restraint Type**	**Restraint Use**	**Total**	**0.00**	**0.01 -0.09**	**0.10+**
Pass Car	Front out	Manual	Belt	7,119	5,260	547	1,312
Pass Car	Front out	Manual	Bag only	1,830	977	189	664
Pass Car	Front out	Manual	Bag+Belt	3,105	2,232	239	635
Pass Car	Front out	Manual	Unrestr	8,014	4,137	743	3,135
Pass Car	Front out	Automatic	Belt	4,708	3,458	365	885
Pass Car	Front out	Automatic	Bag only	167	86	18	63
Pass Car	Front out	Automatic	Bag+Belt	310	242	14	54
Pass Car	Front out	Automatic	Unrestr	1,905	1,032	194	680
Pass Car	Front Ctr	Lap only	Restrain	15	6	2	8
Pass Car	Front Ctr	Lap only	Unrestr	66	40	9	17
Pass Car	Rear	Lap only	Restrain	290	233	27	31
Pass Car	Rear	Lap only	Unrestr	1,405	850	197	359
Pass Car	Rear	Lap+Shld	Restrain	255	183	34	37
Pass Car	Other		Restrain	0	0	0	0
Pass Car	Other		Unrestr	72	46	9	17
LTV/Util	Front out	Manual	Belt	4,567	3,169	337	1,060
LTV/Util	Front out	Manual	Bag only	234	127	15	92
LTV/Util	Front out	Manual	Bag+Belt	371	312	17	42
LTV/Util	Front out	Manual	Unrestr	6,085	2,774	507	2,804
LTV/Util	Front out	Automatic	Belt	6	6	0	0
LTV/Util	Front out	Automatic	Bag only	1	0	0	1
LTV/Util	Front out	Automatic	Bag+Belt	3	3	0	0
LTV/Util	Front out	Automatic	Unrestr	5	3	0	3
LTV/Util	Front Ctr	Lap only	Restrain	30	24	2	4
LTV/Util	Front Ctr	Lap only	Unrestr	161	69	27	66
LTV/Util	Rear	Lap only	Restrain	71	57	4	9
LTV/Util	Rear	Lap only	Unrestr	425	289	44	92
LTV/Util	Rear	Lap+Shld	Restrain	63	49	2	12
LTV/Util	Other		Restrain	16	15	0	1
LTV/Util	Other		Unrestr	379	255	39	85
MC	Driver	Helmet	Restrain	1,610	930	206	475
MC	Driver	Helmet	Unrestr	870	438	108	324
MC	Passenger	Helmet	Restrain	130	73	17	39
MC	Passenger	Helmet	Unrestr	116	46	21	49
Med/Hvy Truck		Lap only	Restrain	204	188	7	9
Med/Hvy Truck		Lap only	Unrestr	490	432	33	25
Other vehs				515	334	36	145
Infant		Belt		3	3	0	0
Infant		Car Seat		168	132	13	23
Infant		Unrestr		98	67	7	24
Toddler		Belt		127	97	8	22
Toddler		Car Seat		247	202	17	28
Toddler		Unrestr		251	189	25	37
Nonoccupants				6,524	3,534	512	2,478
Total				**53,030**	**32,598**	**4,588**	**15,844**
Percentages					**61.5%**	**8.7%**	**29.9%**

The last row of Exhibit 5 presents the newly calculated alcohol percentages. The BAC groups have a different percentage distribution than in Exhibit 4 because the numbers of reportedly restrained occupant fatalities have now been inflated to potential fatalities. Before inflating the figures for restraint effectiveness, the percentage of fatalities in crashes with an intoxicated driver or nonoccupant was 32.4. Because a greater proportion of those in nonalcohol-related crashes was reported to have been restrained, the fatality count in such crashes becomes relatively larger when accounting for restraint use to inflate the figures, and those for alcohol-involved crashes become relatively smaller. Thus, the adjusted figure for fatalities in crashes classified at a BAC of 0.10 or greater, when restraint use is taken in account, is now reduced to 29.9 percent.

All reportedly restrained fatalities were inflated by the effectiveness of each restraint system in each relevant seating position (e.g., front vs. rear and outboard vs. center) to determine the number of potential fatalities. This was done for each year, separating fatalities by vehicle type, seating position, restraint type and reported use, and BAC level. These calculations were then summed to determine the percentages of potential fatalities at each BAC level. These results are shown in the second group of three columns in Exhibit 6. The percentages as calculated directly from FARS, and shown in Exhibit 1, are repeated here for comparison. In 1995, the difference between the adjusted (i.e., the potential rate of alcohol involvement) and unadjusted (i.e., the actual rate of alcohol involvement) figures, for fatalities resulting from crashes at BACs of 0.10 and above, was 2.5 percentage points.

Exhibit 6
Traffic Fatalities by Crash BAC, 1982-1994

	(Actual Fatalities) **BAC level as in FARS**			(Potential Fatalities) **BAC level inflating for restraints**		
Year	**0.00**	**0.01-0.09**	**0.10+**	**0.00**	**0.01-0.09**	**0.10+**
1982	42.7	10.9	46.3	43.0	11.0	46.0
1983	44.5	10.5	45.0	44.7	10.6	44.7
1984	46.3	10.8	42.9	46.7	10.9	42.4
1985	48.2	10.5	41.3	49.0	10.5	40.5
1986	47.8	11.1	41.1	49.1	11.1	39.8
1987	49.0	11.0	39.9	50.6	11.0	38.4
1988	49.8	10.4	39.8	51.8	10.2	38.0
1989	50.8	10.0	39.2	53.0	9.8	37.2
1990	50.5	9.9	39.6	52.8	9.8	37.4
1991	52.1	9.5	38.4	54.6	9.3	36.1
1992	54.5	9.2	36.3	57.0	9.0	34.0
1993	56.5	8.7	34.9	59.1	8.4	32.5
1994	59.2	8.6	32.2	61.9	8.3	29.8
1995	58.7	8.9				
32.4	61.5	8.7				
29.9						

The percentage of fatalities at the highest BAC level, for both the actual and potential fatality populations, are shown graphically in Exhibit 7. With the lower restraint use rates of the early 1980's, there was little difference between the two groups. As restraint use increased, the relationship between belt use and sobriety caused the disparity between the two estimates to increase.

The actual and potential rates of alcohol involvement for the different vehicle types were analyzed separately. Fatally injured occupants of passenger cars, light

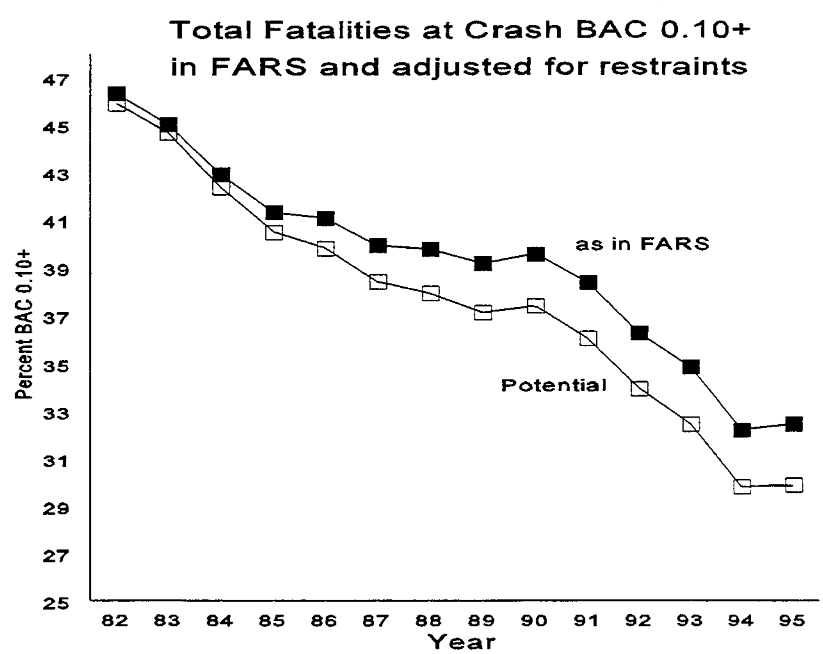

Exhibit 7

trucks, motorcycles, and large trucks are quite different from one another. Differences among these groups, such as trip purpose, crash time of day, and occupant age/sex, influence both restraint use and alcohol involvement. An examination of how each group's pattern of alcohol and restraint use influences potentially fatal crashes could be enlightening.

The annual rates of alcohol involvement for both actual and potential occupant fatalities (age 5 and over) for each vehicle type are shown in Exhibits 8 through 11 for the years 1982 through 1995. The percentages at each BAC level are different among the vehicle types, and differ also from the trend for total fatalities shown in Exhibit 6. For ease of comparison, percentages of actual occupant fatalities at BAC levels of 0.10 and greater are presented in Exhibit 12 for passenger cars, light trucks, motorcycles, and large trucks.

Exhibit 8
Passenger Car Occupant Fatalities
Age 5 and Above
by Crash BAC, 1982-1995

	(Actual Fatalities) **BAC level as in FARS**			(Potential Fatalities) **BAC level inflating for restraints**		
Year	**0.00**	**0.01-0.09**	**0.10+**	**0.00**	**0.01-0.09**	**0.10+**
1982	41.9	11.5	46.6	42.3	11.5	46.2
1983	44.3	10.9	44.9	44.7	10.9	44.4
1984	46.5	11.2	42.3	47.2	11.2	41.7
1985	48.6	10.8	40.6	49.9	10.8	39.4
1986	48.1	11.6	40.3	50.1	11.4	38.5
1987	49.5	11.3	39.2	51.8	11.1	37.1
1988	50.7	10.6	38.7	53.5	10.3	36.2
1989	52.6	10.1	37.3	55.5	9.9	34.6
1990	52.4	10.4	37.2	55.4	10.1	34.5
1991	54.4	9.4	36.1	57.5	9.1	33.4
1992	56.8	9.2	34.0	59.8	8.9	31.3
1993	59.0	8.8	32.2	61.9	8.4	29.7
1994	61.5	8.7	29.8	64.7	8.3	27.0
1995	61.3	9.2	29.6	64.2	8.8	27.0

Exhibit 9
Light Truck, Van and Utility Vehicle Occupant Fatalities
Age 5 and Above
by Crash BAC, 1982-1995

	(Actual Fatalities) **BAC level as in FARS**			(Potential Fatalities) **BAC level inflating for restraints**		
Year	**0.00**	**0.01-0.09**	**0.10+**	**0.00**	**0.01-0.09**	**0.10+**
1982	35.7	10.4	54.0	36.0	10.4	53.6
1983	37.1	9.5	53.4	37.6	9.5	53.0
1984	39.8	10.7	49.5	40.2	10.8	49.0
1985	42.2	9.7	48.1	42.8	9.6	47.6
1986	41.8	10.2	48.0	43.2	10.4	46.4
1987	42.4	10.6	47.0	44.4	10.6	45.0
1988	41.4	10.1	48.5	43.8	9.9	46.3
1989	43.9	9.7	46.5	46.6	9.5	43.8
1990	43.2	9.6	47.2	46.4	9.2	44.4
1991	44.8	9.6	45.6	48.1	9.4	42.5
1992	48.4	9.1	42.4	51.8	8.9	39.3
1993	50.8	8.1	41.0	54.3	7.9	37.7
1994	53.3	8.2	38.5	56.7	8.0	35.3
1995	53.3	8.3	38.4	57.6	8.0	42.4

Exhibit 10
Motorcycle Occupant Fatalities
by Crash BAC, 1982-1995

	(Actual Fatalities) **BAC level as in FARS**			(Potential Fatalities) **BAC level inflating for restraints**		
Year	**0.00**	**0.01-0.09**	**0.10+**	**0.00**	**0.01-0.09**	**0.10+**
1982	39.5	14.0	46.5	40.4	14.0	45.6
1983	38.5	14.3	47.2	39.0	14.4	46.6
1984	39.9	14.3	45.8	40.7	14.5	44.9
1985	40.5	14.3	45.2	41.4	14.3	44.3
1986	39.6	14.0	46.4	40.5	14.0	45.5
1987	43.2	14.1	42.7	44.2	14.0	41.8
1988	44.9	14.2	40.9	45.8	14.1	40.2
1989	41.9	13.5	44.6	42.9	13.3	43.9
1990	42.3	13.3	44.3	43.0	13.3	43.7
1991	44.1	13.2	42.7	45.0	12.9	42.1
1992	46.4	13.5	40.1	47.3	13.4	39.3
1993	50.1	12.5	37.4	50.7	12.5	36.8
1994	54.6	12.1	33.3	55.4	11.8	32.8
1995	53.8	12.9	33.2	54.6	12.9	32.5

Exhibit 11
Medium/Heavy Truck Occupant Fatalities
Age 5 and Above
by Crash BAC, 1982-1995

	(Actual Fatalities) **BAC level as in FARS**			(Potential Fatalities) **BAC level inflating for restraints**		
Year	**0.00**	**0.01-0.09**	**0.10+**	**0.00**	**0.01-0.09**	**0.10+**
1982	76.8	6.0	17.2	76.7	6.0	17.3
1983	77.0	6.4	16.6	77.0	6.4	16.6
1984	78.5	6.5	14.9	78.6	6.6	14.9
1985	81.7	5.4	12.9	81.9	5.3	12.8
1986	83.2	6.1	10.7	83.4	6.1	10.5
1987	84.0	5.0	11.0	84.1	5.1	10.8
1988	83.3	5.8	10.9	83.7	5.6	10.7
1989	81.7	7.0	11.3	81.8	7.0	11.2
1990	81.9	6.9	11.2	81.9	7.0	11.1
1991	84.6	6.4	9.1	84.6	6.3	9.1
1992	89.7	3.4	6.9	90.1	3.4	6.6
1993	87.8	5.0	7.3	88.0	4.9	7.1
1994	90.4	3.3	6.2	90.5	3.4	6.1
1995	89.1	5.9	5.0	89.3	5.7	10.7

Passenger cars, light trucks, vans, and utility vehicles combine to form the passenger vehicle group, but there are differences in their driver alcohol involvement rates. Over 46 percent of passenger car occupant fatalities were in crashes at a BAC level of 0.10 and above in 1982. Since then, this percentage has decreased, down to its 1995 value of less than 30 percent, an overall decrease of 36 percent. Light trucks, vans, and utility vehicles had a higher percentage of fatalities in crashes at BAC levels 0.10 and above, 54.0 in 1982, but this too has steadily decreased to its 1995 level of 38.4 percent, for an overall decrease of 29 percent.

Crash BAC levels for motorcycle fatalities have not changed as dramatically over the same period of time. The 0.10 and greater BAC percentage fell from 46.5 in 1982 to 33.2 in 1995, a decrease of 29 percent. Larger trucks, on the other hand, started out with relatively low BAC 0.10+ rates (17.2), and fell to just 5.0 percent, a decrease of 71 percent.

Exhibits 13 and 14 present tables of restraint use rates for fatalities in passenger cars, light trucks, motorcycles, and large trucks, as computed from FARS and in potentially fatal crashes, respectively. Fatalities in passenger cars show a definite pattern of increasing restraint use from 1982 to 1995, from 3 percent to 40 percent. Passenger car occupant restraint use in potentially fatal crashes increased from 5 percent to 54 percent over these same years.

Motorcycle helmet use, on the other hand, began at a much higher rate, and has remained relatively stable over the years. Occupant restraint use in light and large trucks increased, but not as sharply as in passenger cars.

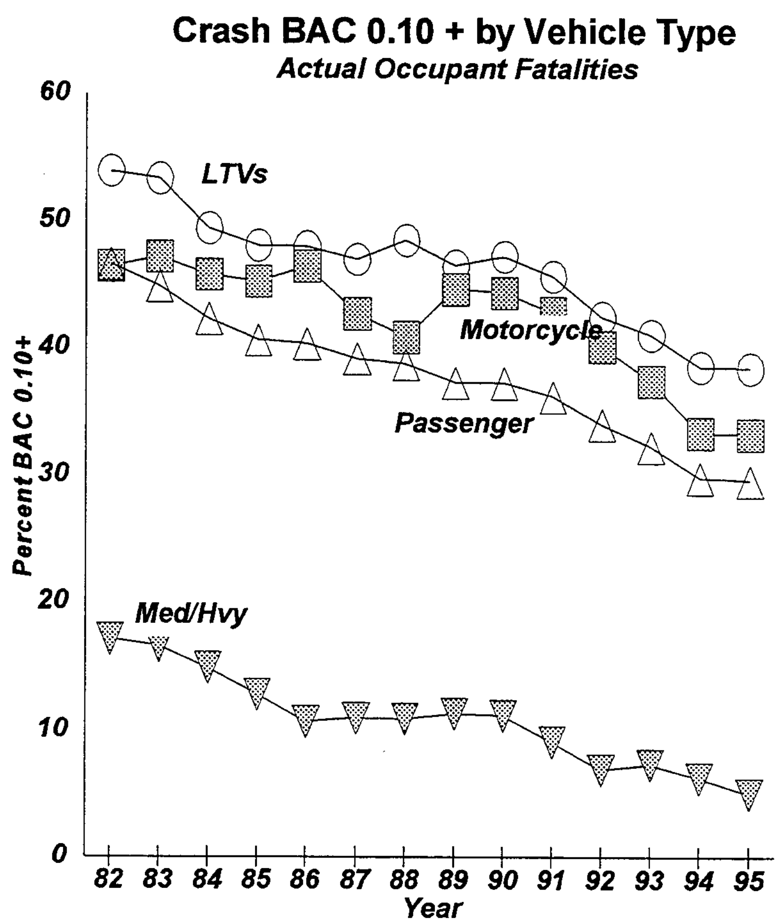

Exhibit 12

Exhibit 13
Restraint Use Rates for Fatalities
by Vehicle Type as Reported in FARS

Year	Passenger Cars	Light Trucks, Vans, Utilities	Motorcycles	Medium and Heavy Trucks
1982	3	1	45	2
1983	4	2	42	3
1984	5	3	43	2
1985	11	5	42	5
1986	17	8	43	10
1987	20	10	40	11
1988	23	11	40	11
1989	25	13	41	13
1990	26	13	45	16
1991	30	15	46	18
1992	33	17	56	25
1993	37	20	57	21
1994	39	21	55	21
1995	40	23	56	24

Exhibit 14
Restraint Use Rates in Potentially Fatal Crashes
by Vehicle Type

Year	Passenger Cars	Light Trucks, Vans, Utilities	Motorcycles	Medium and Heavy Trucks
1982	5	3	53	3
1983	6	4	51	3
1984	9	6	52	3
1985	18	11	51	7
1986	26	18	52	13
1987	31	22	49	15
1988	35	23	49	14
1989	37	26	50	16
1990	39	28	54	20
1991	44	30	54	23
1992	47	34	65	31
1993	51	37	65	27
1994	53	40	63	26
1995	54	41	64	29

The restraint use rates for occupant fatalities as reported in FARS are shown in Exhibit 15. While occupants of passenger cars, light trucks, and medium and heavy trucks initially used restraints at the same low rates, passenger cars have had the sharpest regular increase in restraint use. Motorcyclists have used helmets at a much higher rate, but there has been no consistent increase over time, as was observed for other vehicle types. Occupants of both motorcycles and medium and heavy trucks, however, exhibited a sharp increase in restraint use in 1992 over 1991. (Note: Much of the increase in motorcyclist helmet use can be traced to the January 1992 effective date for California's mandatory helmet use law; in 1995, California accounted for nearly 12 percent of all U.S. motorcyclist fatalities.)

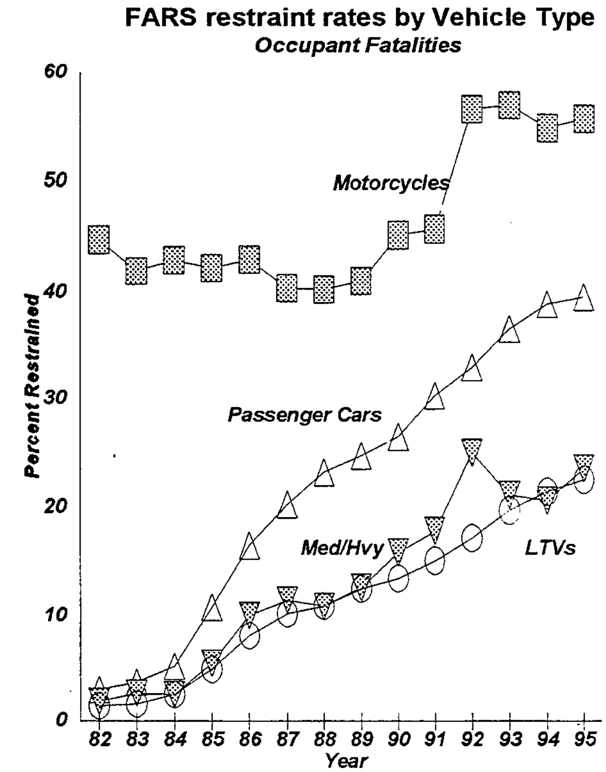

Exhibit 15

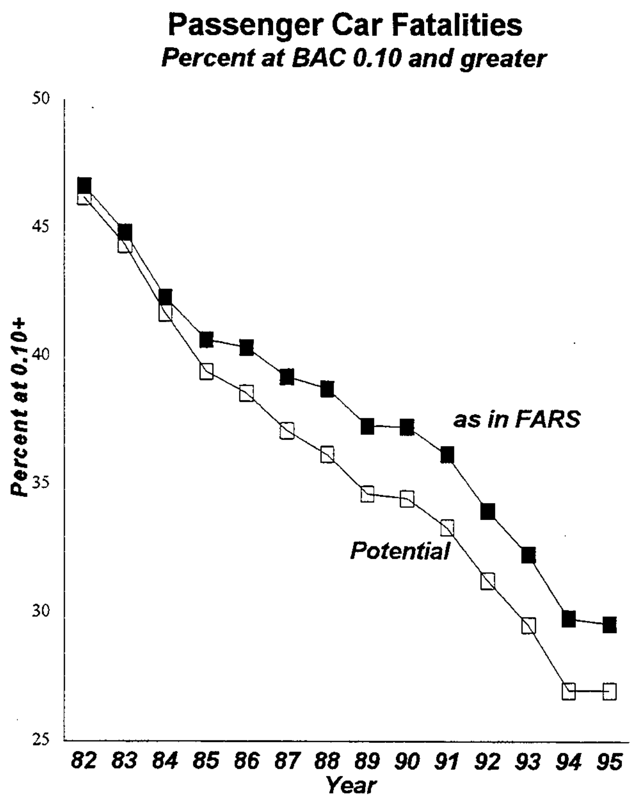

Exhibit 16

Since restraint use directly affects the adjustment for potential fatalities within the BAC levels, the most dramatic change will be observed in the rates for passenger cars. Exhibit 16 shows graphically the actual and potential alcohol involvement rates for passenger car occupant fatalities at BAC levels 0.10 and above. Comparing this figure to Exhibit 7, it can be seen that passenger car occupants have a more pronounced decline when adjusted for restraint use than do total fatalities.

An alternative method of examining changes in the BAC distribution due to adjusting for restraint use would be to compare differences in changes over time. For example, in 1982, 46.3 percent of all traffic fatalities were in crashes with BACs of 0.10 or above. (These data were shown in Exhibit 6.) This percentage dropped to 32.4 in 1994, a decrease of 30 percent. When examining potential fatalities (i.e., adjusted for restraint use), however, the alcohol involvement rate declined from 45.9 percent in 1982 to 29.9 percent in 1995, a decrease of 35 percent. The percentage changes from 1982 to 1995, for occupants of the various groups of vehicles, are shown in Exhibit 17 for crashes involving any alcohol as well as those with BAC $\geq$ 0.10. Note that groups involving passenger vehicles (passenger cars and light trucks) show the most marked difference between actual (i.e., as recorded in FARS) and potential fatalities. Since the majority of traffic fatalities are passenger vehicle occupants, the group of total fatalities also shows a relatively large difference when adjusted for restraints.

Exhibit 17
Percentage Change in Percent of Fatalities
in Crashes Involving Alcohol
1982 to 1995

	(Actual Fatalities) **BAC level as in FARS**		(Potential Fatalities) **BAC level inflating for restraints**	
	0.01+	0.10+	0.01+	0.10+
All fatalities	-28	-30	-32	-35
Passenger vehicle fatalities	-31	-33	-36	-39
Passenger car fatalities	-33	-37	-36	-39
LTV fatalities	-28	-29	-34	-36
Motorcyclist fatalities	-24	-28	-24	-29
Med/Hvy truck fatalities	-53	-71	-54	-71

Alcohol involvement among motorcyclist fatalities decreased by 24 percent, using either the actual FARS data or potential fatalities. This is not surprising, since motorcycle helmet use has remained at a fairly steady rate over the years covered in this report, and alcohol use patterns have not changed as much as they have for drivers of other vehicle types. Therefore, no corresponding differences emerge for motorcycle fatalities when alcohol rates are adjusted for restraint use.

Large truck occupants, however, did increase restraint use over the years, but they do not show a large difference in alcohol involvement. Examination of the data shows very low alcohol involvement for large truck occupant fatalities, regardless of restraint use. Among potential fatalities there is even less difference for the restrained vs. unrestrained in this group.

NHTSA's method of determining crash-level alcohol involvement is based upon the joint likelihood of alcohol involvement among all active participants. Thus, when a drunk driver or pedestrian is involved in a fatal crash, everyone in the crash, whether they had been drinking or not, is considered alcohol involved. Occupants in crashes not involving alcohol are more frequently restrained than those in alcohol-involved crashes, and are therefore inflated in a greater proportion when restraint effectiveness is taken into account. However, nondrinking occupants (who are restrained) do become involved and fatally injured in crashes with drinking drivers, and thus, since they enter into the computation of potential fatalities and are considered alcohol involved at the crash level, this dilutes the effect of the alcohol vs. restraint use relationship.

Discussion

Several extreme examples of the long-term effect of ignoring the alcohol involvement-restraint use interaction were investigated using data for calendar year 1995. As noted earlier, the **actual rate of alcohol involvement** for the 41,795 fatalities in 1995 was 41.3 percent. After accounting for the effects of restraint use, the **potential rate of alcohol involvement for fatalities** was calculated to be 38.5 percent.

What if occupant protection program efforts for 1995 resulted in 100 percent belt use among passenger car occupants in fatal crashes where no driver or pedestrian had been drinking (that is, crashes at a BAC of 0.00)?

Example 1: 100 percent belt use among sober passenger car occupant fatalities

	Example 1	Actual 1995
Fatalities	38,867	41,795
Addl Saved by Belts	2,928	
Observed Alcohol Rate	44.7%	41.3%

In this scenario, great progress in total fatalities would have been observed. Instead of the 41,795 total fatalities, there would have been only an estimated 38,867 fatalities, a savings of over 2,900 lives. However, the **actual rate of alcohol involvement** observed in the FARS data would have been 44.7 percent, an apparent increase of 3.4 percentage points from the 41.3 percent that actually occurred in 1995. Thus, even though the **actual** prevalence of alcohol involvement on the roadways would not have changed, there would have been an **observed** increase in alcohol involvement among total fatalities because of the increased lives saved by restraints in sober fatal crashes.

Example 2 below repeats the simulation exercise for fatally injured occupants of all passenger vehicles (cars and light trucks collectively).

Example 2: 100 percent belt use among sober passenger car and light truck occupant fatalities

	Example 2	Actual 1995

Fatalities	36,924	41,795
Addl Saved by Belts	4,871	
Observed Alcohol Rate	47.1%	41.3%

If we apply the same situation to both passenger car and light truck occupants in fatal crashes at a BAC of 0.00, the **actual rate of alcohol involvement** observed among the even fewer estimated 36,924 fatalities would have been an even higher, 47.1 percent. The increase in lives saved by the use of occupant restraints further distorts the observed rate of alcohol involvement among fatalities. Adding motorcycle helmets to all motorcyclists in fatal crashes at a BAC of 0.00 would yield an **actual rate of alcohol involvement** of 47.2 percent.

In each of these scenarios, the **potential rate of alcohol involvement** in fatal crashes remains at the same 38.1 percent level. Clearly, the above calculations are worst-case scenarios since restraint use would also have been higher among some alcohol-involved fatalities who themselves had not been drinking, resulting in somewhat lesser increases in the **observed** rate of alcohol involvement.

Adding air bags to all passenger vehicles (without any change in existing safety belt use) would have little change in the actual rate of alcohol involvement, since this would affect all fatalities across the board. However, drivers of older vehicles exhibit higher rates of alcohol involvement than do drivers of newer vehicles [13], yielding the possibility of transitional effects on the observed rate of alcohol involvement until the entire on-road fleet consisted of air bag-equipped passenger vehicles.

Therefore, it is **critical** to consider changes in the **potential rate of alcohol involvement** in order to isolate the trend in alcohol involvement from its interaction with occupant protection efforts. Neglecting to do so ignores the fact that alcohol has been declining at a greater rate than demonstrated by the actual FARS data, and could result in apparent increases in fatal crash alcohol involvement as a result of gains in restraint use and a continuation of the alcohol-restraint use experience.

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