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

NHTSA
People Saving People
www.nhtsa.dot.gov

DOT HS 809 019

January 2000

Drinking and Driving in the United States:

The 1996 National Roadside Survey

DRINKING AND DRIVING IN THE UNITED STATES: THE 1996 NATIONAL ROADSIDE SURVEY

prepared for:

Department of Transportation
National Highway Traffic Safety Administration
400 7th Street, SW
Washington, DC 20590

prepared by:

Robert B. Voas*

JoAnn Wells**

Diane C. Lestina*

Allan Williams**

Michael Greene***

*Pacific Institute for Research and Evaluation
7315 Wisconsin Avenue, Suite 1300 West
Bethesda, MD 20814, USA

**Insurance Institute for Highway Safety
1005 N. Glebe Road, Suite 800
Arlington, VA 22201, USA

***U.S. Consumer Product Safety Commission
Washington, DC 20207, USA

January 3, 2000

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
Drinking and Driving in the United States: The 1996 National Roadside Survey	1-18-2000
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Robert B. Voas, Allan Williams, JoAnn Wells, Michael Greene, Diane C. Lestina	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Pacific Institute for Research and Evaluation 7315 Wisconsin Avenue, Suite 1300 West Bethesda, MD 20814 Phone: 301-951-4233 Fax: (301) 907-8637	11. Contract or Grant No.

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Department of Transportation National Highway Traffic Safety Administration 400 7th Street, SW Washington, DC 20590	14. Sponsoring Agency Code

15. Supplementary Notes

James Fell served as the Contracting Officer's Representative for the study.

16. Abstract

Following the same general principles of its two predecessors in 1973 and 1986, the 1996 National Roadside Survey of weekend, nighttime drivers in the 48 contiguous states consisted of interviewing and breath testing over 6000 noncommercial four-wheel vehicle operators between September and November, 1996. Results indicated that the total number of drinking drivers fell by about one-third between 1986 and 1996; however, there was no significant change in the number of drivers at BACs (blood alcohol concentrations) at or above 0.05. Thus, the decrease results from fewer drivers with BACs of .05 or below. Compared to 1973, the proportion of women drivers on the roads during weekend nights has increased significantly. Moreover, relative to males, the proportion of female drivers who have been drinking has increased over the last decade. The number of drivers under the age of 21 with a BAC at or above 0.10 decreased significantly from 1986 to 1996.

17. Key Words	18. Distribution Statement
National Roadside Survey, Driving Under the Influence, Driving While Intoxicated, Alcohol	

19 Security Classif. (of this report)	20. Security Classif. (of this page)	21 No. of Pages	22. Price
Unclassified	Unclassified		

Form DOT F 1700.7 (8/72) Reproduction of completed page authorized

EXECUTIVE SUMMARY

The Fatality Analysis Reporting System (FARS), a census of fatal crashes in the United States, contains a measured or estimated blood alcohol concentration (BAC) for the drivers and pedestrians involved in such crashes. This provides the primary indicator of the extent of alcohol involvement in the U.S. highway safety problem. Complementary data are provided by national roadside surveys, which determine the proportions of drivers exposed to involvement in alcohol-related crashes. This information allows the calculation of the relative risk of crash involvement at various BAC levels and the measurement of trends in drinking and driving over time. Three national roadside surveys have been conducted in the United States: one in 1973,a second in 1986, and a third in 1996. This report describes the third survey conducted between September 6 and November 9, 1996.[1]

Like its predecessors, the 1996 survey covered the 48 contiguous states. As with the original 1973 survey, it used a four-stage sampling plan (the 1986 survey attempted to replicate the 1973 locations). In 1996, the first stage was taken from the National Automotive Sampling System/Crash Worthiness Data System (NASS/CDS, 1995). The second stage involved the selection of police jurisdictions within the NASS/CDS primary sampling units. The third stage of the sampling design involved the selection of survey sites within police jurisdictions, and the fourth stage consisted of selecting drivers at random from the traffic flow at those sites.

Surveys were conducted during two periods: 10 PM to 12 AM and 1 AM to 3 AM on Friday and Saturday nights. Commercial vehicles and motorcycles were excluded from the sample. Vehicles were directed into a safe, off-road location by a police officer, where an interviewer approached the motorist and requested that he or she participate in a 5-minute interview followed by a breath test. Random selection of drivers was assured by selecting the next vehicle once an interviewer became available. Any driver with a BAC at .05 or greater was provided with a ride home. The high level of participation in all three national surveys is shown in Table 1. As can be seen almost twice as many drivers were interviewed in the 1996 survey as in the earlier surveys.

TABLE 1. PROPORTION OF DRIVERS ENTERING THE SURVEY SITES WHO PROVIDED INTERVIEWS AND BREATH TESTS

Drivers	1973	1986	1996
Entered site	3,698	3,043	6,298
Provided interview	3,353 (90.7%)	2,971 (97.6%)	6,045 (96.0%)
Provided interview breath sample	3,192 (86.3%)	2,850 (93.7%)	6,028 (95.7%)

1 This study was jointly funded by the Insurance Institute for Highway Safety and the National Highway Traffic Safety Administration. The authors wish to acknowledge the assistance of Art Wolfe, who provided questionnaires, survey protocols, and data from the previous national surveys; James Fell, who participated in the development and management of the effort; Michele Fields, who provided legal assistance in coordination with local police and attorneys; and Chuck Farmer, who assisted in the analysis of the data.

Results of the 1996 survey are shown in Table 2. Compared to the 1986 survey conducted a decade earlier, there was a significant reduction in the number of drivers on the road with BACs in the low range between .01 and .05. However, there was no statistically significant reduction in drivers with higher BACs. Though there was a slight decrease in male drivers with BACs greater than .05, there was an increase in female drivers at the higher BACs. Drivers under age 21 had a large decrease in the percentage of drivers with BACs at or greater than .10, from 2.7% to 0.3%. While the percentage of African Americans with high BACs decreased between 1986 and 1996, the proportion of Hispanics with BACs at .05 or greater increased.

TABLE 2. COMPARISON OF THE PERCENTAGE OF DRIVERS IN VARIOUS BAC CATEGORIES IN 1986 AND 1996

	% of Drivers			
BAC Interval	**1986**	**1996**	**Diff.**	t_{Diff}
.000 - .004	74.1	83.1	9.0	2.66*
.005 - .049	17.6	9.2	-8.4	-4.99*
.050 - .099	5.2	5.0	-0.2	-0.18
.100+	3.2	2.8	-0.4	-0.41

* Significant at p<.05

TABLE OF CONTENTS

Form DOT F 1700.7 ii

Executive Summary iii

Table of Contents v

Introduction 1

National Survey Sampling Plan 1

Survey Procedures 4

Breath Alcohol Measurements 5

Data Analysis 6

Survey Results 6

Discussion 11

References 14

Appendix A. Survey 16

Appendix B. Sampling Procedures and Survey Methodologies for the 1996 Survey with Comparisons to Earlier National Roadside Surveys 17

INTRODUCTION

Thirty years ago when the Department of Transportation (DOT) was established, the fact that alcohol was an important factor in traffic crashes was well understood. The new agency that was to become the National Highway Traffic Safety Administration (NHTSA) delivered a report to the Congress on Alcohol and Highway Safety in 1968 that pointed to the need for improved data on drinking and driving. This led to the establishment of incentives for the states to conduct blood alcohol concentration (BAC) tests on all fatally injured drivers and pedestrians and eventually, to the establishment of the Fatality Analysis Reporting System (FARS) in 1975.[2] Initially, BAC data in this file was limited because state testing for alcohol was infrequent. Since 1982, through the use of an imputation system (Klein, 1986), it has provided a reliable means of assessing the national progress in reducing fatal crashes in which drivers have been drinking.

The FARS has been augmented by a series of national roadside breath-test surveys that determine the number of drinking drivers on the roads in the contiguous 48 states. The first of these surveys was conducted in 1973 and a second in 1986. This paper reports on the third national survey conducted in the fall of 1996 and its relation to trends in alcohol-involved crashes in the United States. The objective of the present study and of the earlier studies was to measure changes in the number of drinking drivers on the roads at-risk for becoming involved in alcohol-related fatal crashes. With these data, investigators can calculate the relative risk of crash involvement at each BAC level (Zador, 1991). The three national surveys and the FARS (NHTSA, 1995) document the reductions in the number of drinking drivers on American roadways and the resulting reductions in highway deaths and injuries over the last two decades. Despite this reduction, 17,126 road users died in alcohol-related crashes in 1996 (NHTSA, 1995).

NATIONAL SURVEY SAMPLING PLAN

It is obviously impossible to conduct surveys on all the roads in America. It was, therefore, necessary to construct a sampling system that was representative of the United States but required interviewing only a few thousand of the more than 175 million drivers who were using American roads in 1996. Thus, it was necessary in the 1996 survey, as in the two previous national roadside surveys, to limit the area covered to the 48 contiguous states. All three surveys were conducted between 10 PM and 12 AM and between 1 AM and 3 AM on both Friday and Saturday, when heavy drinking is most likely to occur and alcohol-involved crashes are most frequent (NHTSA, 1995). From a practical standpoint, these national surveys had to limit survey locations to roadways with sufficient traffic to provide enough interviews to justify the expense of employing a survey crew. Thus, counties with populations of less than 20,000 were not surveyed. In counties with larger populations, only roadways with 2,000 to 4,000 average daily traffic counts were included in the survey. Finally, commercial operators could not be asked to take time from their employment to be interviewed, and motorcyclists were not included because arrangements to drive their vehicles to their homes could not be made if

[2] Originally named "Fatal Accident Reporting System."

necessary. In any case, there are too few motorcyclists on American roads to provide an adequate sample for analysis. This means that the results from all three national surveys provide information on private four-wheel vehicle operators at locations and during periods when drinking and driving is most prevalent. Therefore, these results are not typical of all drivers at all times or on all roadways in the United States.

The 1973 and 1996 national surveys made use of multistaged samples developed to be representative of the 48 contiguous states in the year the data were collected. The 1986 survey attempted to use the same locations used in 1973. In 1996, the initial sample structure was taken from the National Automotive Sampling System/Crashworthiness Data System (NASS/CDS, 1995). The first stage of the 1973 and 1996 sample designs was the selection of primary sampling units (PSUs) made up of cities, large counties, or groups of counties from within four regions of the United States and three levels of population density. The second step was to select from a list of the police jurisdictions (PJs) within each of the selected PSUs that would be invited to participate in the survey. The third step was to select survey sites within the geographical area of the selected PJs by placing a grid over a map of the area and randomly selecting 1-square-mile cells within which the survey sites would be located. Finally, drivers to be interviewed were selected at random from the traffic passing through the survey site.

These sampling procedures were followed to ensure that the probability of selecting a PSU and a PJ survey location and driver was known at each of these stages in the sample design. Knowing these probabilities allowed the computation of the probability that each individual driver would be interviewed in the survey. This was done by multiplying the sampling probabilities at each of the four stages to obtain the final overall probability of being sampled. The weight given to each case in the final totals (sampling weight) was then computed as the inverse of the sampling probability—that is, data from drivers who were unlikely to be interviewed based on the sampling procedure used were given more weight than data from drivers who were more likely to be interviewed. This ensured that the basic requirement of the sampling theory—that is, every driver has an equal chance of being interviewed—was met by adjusting for the biases inherent in the selection of locations within the sampling frame. A more detailed description of the sampling procedure is provided in Lestina, Greene, Wells, and Voas (1999).

The major barrier to carrying out this staged sampling scheme was obtaining police department support for the survey. In some localities, city attorneys or the police leadership believed that legal limitations to stopping vehicles or potential liability prevented their participation in the surveys. In other cases, the police departments reported that they lacked the personnel resources to support the effort. This resulted in the requirement to make substitutions in all three national surveys for initially selected PSUs and PJs where enforcement assistance was not available. Substitutions were required for 5 PSUs in the 1973 survey, 9 PSUs in the 1986 survey, and 5 PSUs in the current survey. The effect of these departures from the original structure of the sample was minimized by ensuring that the substitute was selected from the same geographical and population stratum. The 24 PSUs used in the 1996 survey are shown in Figure 1.

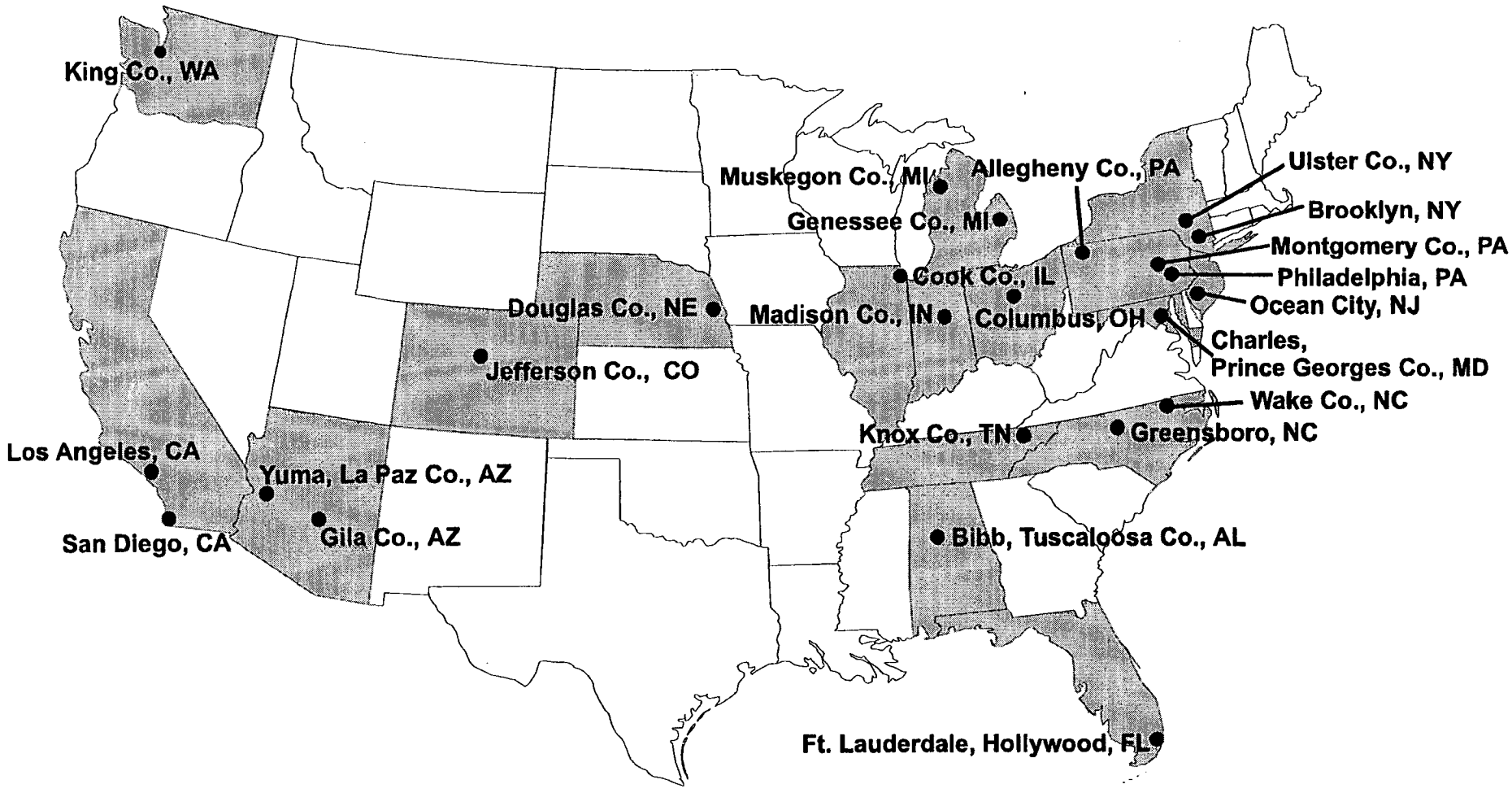


FIGURE 1. 1996 NATIONAL ROADSIDE SURVEY PRIMARY SAMPLING UNIT LOCATIONS

SURVEY PROCEDURES

The roadside survey procedures implemented in 1996 followed, as closely as possible, those used in the previous two national surveys (Lestina et al., 1999). Three civilian survey teams of three interviewers each, one of which was appointed the team leader, were selected and trained during the last week in August 1996. Each team was assigned a set of PSUs—roughly based on geographical locations—in the east, midwest, and far west regions of the country. Surveys were conducted between 10 PM and 12 AM and between 1 AM and 3 AM on both Friday and Saturday beginning with the weekend of September 6 and 7 and concluding 10 weeks later on the weekend of November 8 and 9, 1996.

Team leaders arrived at their PSUs on the Thursday before the survey and visited the proposed survey sites with their liaison officers from the cooperating police departments. The other two team members arrived on Friday in time to meet with officers before departing for the survey sites. An effort was made to identify three different sites for each of the two survey periods on both Friday and Saturday nights for a total of 12 sites in each of the 24 PSUs.[3] Some departments were not able to supply the needed three officers; in those localities, only two locations were surveyed during each period. In San Diego, California, and Cook County, Illinois, where the surveys were conducted as part of sobriety checkpoint operations, only one location was used each night.

Once at the site, an officer positioned a police vehicle with its overhead lights flashing so that it could be seen by traffic approaching the site. Also, the vehicle's headlights illuminated the officer. Where possible, the interviewer worked in an off-road parking lot. In some cases, the interview had to be conducted at the side of the road. When ready, the interviewer signaled the officer who flagged down the next vehicle that could be safely stopped and directed the driver to the interview site. After the motorist entered the site, he or she had no further contact with the police officer. Motorcycles and commercial vehicles were excluded from the survey.

To ensure that a random sample of motorists was selected for the survey, it was necessary to bring the next available vehicle into the survey site when an interviewer was ready for a respondent. In practice, a few of the selected motorists were missed because they turned away from the site and the officer was unable to signal them in time, or, having spoken with the motorist, the officer allowed the individual to proceed without entering the site. The number of such cases was not reported in the 1973 survey. In 1986, 6.7%, and in 1996, 2.8% of the motorists the police attempted to stop did not enter the survey sites. (The weighting of the data in the analysis of the survey ensured that those motorists, selected but not entering the site, were imputed to have the same distribution of BAC values as those interviewed and tested at the same site.)

Once the motorist came to a safe stop, the interviewer approached, explained that the survey was voluntary and anonymous, and obtained informed consent for a brief interview (see Appendix A—Survey). The interviewees answered 15 questions

[3] Twelve sites in each of the 24 PSUs were planned for a total of 288 sites. Due to locations where there was light traffic, poor weather conditions, and inadequate manpower, the actual number of sites was 209. At least two sites were surveyed in each PSU.

covering topics such as their annual mileage, the origin and destination of their trip, drinking, drinking and driving, and whether they were acting as a designated driver. In addition, the interviewer recorded his or her observations of the number of passengers, use of a safety belt by the driver, and the gender and ethnicity of the driver. A passive alcohol sensor (PAS) reading and an alcohol breath test were also obtained. The average time with each motorist was 5 minutes. Interviewers, equipped with a mobile phone, assisted drivers with BACs greater than .05 in obtaining a ride home by taxi or from a friend if a sober passenger was not available. At some locations, local volunteers provided transportation for those with BACs of .05 or greater. A full description of the survey methodology is provided in a published article, *Sampling Procedures and Survey Methodologies for the 1996 Survey with Comparisons to Earlier National Roadside Surveys*, in Appendix B.

BREATH ALCOHOL MEASUREMENTS

Blood alcohol concentration was measured using a handheld test device, the SD-400 (1995), which was tested by NHTSA and placed on its Conforming Products List for Evidential Breath-Test Devices (NHTSA, 1993). To test with this device, a small tube is placed over the inlet and the respondent is requested to take a deep breath and blow slowly through the tube. Because some respondents refuse to provide a breath test and others are not able to blow sufficient air to provide a valid sample, a PAS that can detect alcohol in the expired air around the face (Kiger, Lestina, & Lund, 1993) was also used in the 1986 survey. Correlating these PAS readings with the BACs of those drivers on whom both test measures were obtained provided a basis for the imputations of BAC measures for respondents not breath tested in the survey. The Public Services Technologies, Inc. PAS unit used in the current survey employs the same fuel cell alcohol detector as the SD-400 (1995) evidential unit. Rather than requiring a mouth piece, however, it has a small electrical pump that pulls in air from in front of the subject's face (Cammisa, Ferguson, & Wells, 1996; Fiorentio, 1997). When the PAS is held within 6 inches of the face and the pump is activated, it provides a rough indication (correlation about .70 in the present study) of the individual's BAC.

After the motorist entered the site, he or she was given an opportunity to volunteer to provide a confidential, anonymous interview and breath test. The number of interviews and breath tests provided by motorists in each of the national surveys is shown in Table 1. In 1996, 6,298 drivers entered the survey site with 6,045 (96%) providing an interview and 6,028 (95.7%) providing a breath sample. As can be seen, the percentage of drivers providing valid breath measurements has increased from 86% to 96% across the three surveys. In 1996, of the 270 drivers entering the survey site for whom there is no test result, 74 agreed to blow into the device but were not able to produce enough air to provide a valid measure, and 196 refused to provide a sample.

As expected, there was a tendency for those who refused, and those who claimed to be unable to produce a sample, to have higher PAS scores than those who agreed to be tested. This is in line with the experience in the other national surveys where those who refused the breath test were estimated to have higher BACs (Wolfe, 1974; Lund & Wolfe, 1991). Based on the relationship demonstrated between the PAS and the SD-400 (1995) breath-tester reading for the 5,400 cases in

which both measures were available, an estimate was made of the BAC for each of the interviewees where only the passive sensor measure was available. PAS readings were not available for about one-half of the people who did not provide breath samples because there was no opportunity to bring the sensor close enough to the participant to obtain a measure. For such people, the marginal BAC distribution was computed separately for the 196 who refused and the 74 who were unable to provide breath samples. These marginal distributions were used to impute the BACs of those respondents (see Appendix B).

DATA ANALYSIS

The multistage sampling system (described above) provided unbiased estimates of national totals (Sarndal, Swensson, & Wretman, 1992, p. 43). In the current 1996 survey, the SUDAAN program (Shah, Barnwell, & Bieler, 1995) was used to compute those estimates. This program takes into account the correlation between elements of the sampling frame in computing variances for each variable in the survey. To compare the 1996 survey with the two earlier surveys, their data were entered into the same SUDAAN program for analysis to compute the variances for cross-survey comparisons. Two analyses were performed: single variable comparisons using the error terms generated by the SUDAAN program and a multifactor logistic regression using odds ratios to determine the measures significantly related to having a high BAC (.05 or greater) at the roadside when the influence of other factors was held constant.

SURVEY RESULTS

The results for the 1996 survey compared to the two earlier surveys are shown in Figure 2. Like the 1986 survey, the 1996 results show lower percentages of drinking drivers at all BACs than in 1973. However, the largest declines among the drinking drivers in the last decade have occurred at the lowest BACs, not at the higher-risk concentrations higher than .05. This is shown in Table 2 where the number of nondrinking drivers (BACs .000 to .004) was significantly greater in 1996 than in 1986, and the number of drivers in the .005 to .049 BAC category is significantly smaller in the 1996 survey than in 1986. Yet, there is no significant statistical change in the percentage of drivers in the .050 to .099 and .10 and higher, BAC categories. Thus, while the overall percentage of drinking drivers on the road on weekend evenings has declined steadily since 1973 (as shown in Figure 3), it is important to remember that the small reduction in the percentage of the highest risk drinking drivers was not statistically significant.

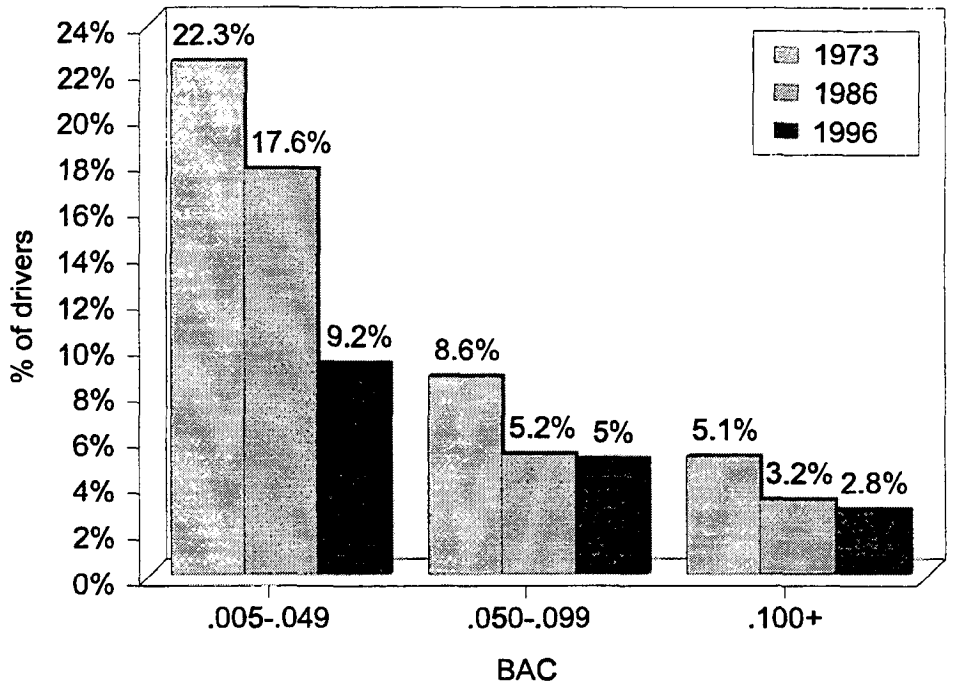


FIGURE 2. BLOOD ALCOHOL CONCENTRATIONS (BACS) OF DRINKING DRIVERS IN NATIONAL SURVEYS

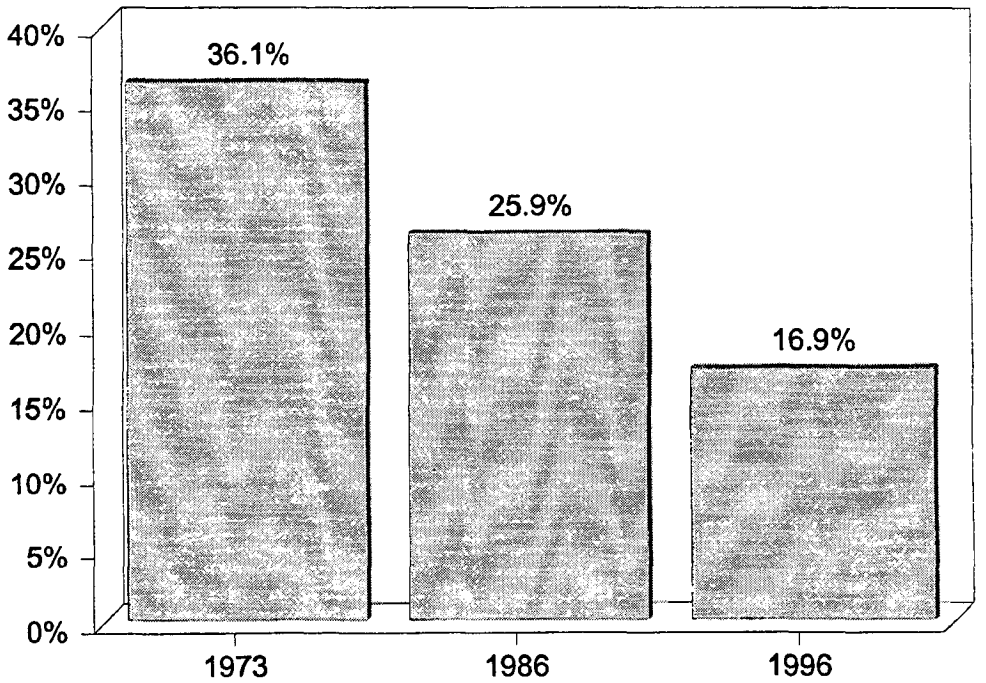


FIGURE 3. PERCENTAGE OF WEEKEND NIGHTTIME DRIVERS WITH POSITIVE BACS ON U.S. ROADS

Despite the lack of significant change between 1986 and 1996 in the percentage of drivers with BACs at or greater than .050, the single variable analysis uncovered some interesting trends in the data that are shown in Tables 3 and 4. Table 3 presents the BACs of drivers in the three surveys by the time of night and weekend night. As was the case in the 1986 survey, the 1996 results show lower percentages of high BAC drivers than in 1973 at both the earlier and later hours on both Friday and Saturday nights. However, in comparing 1996 with the

1986 results, these data suggest that reductions between 1986 and 1996 have primarily occurred earlier in the evenings (10 PM to 12 AM) on both Fridays and Saturdays, and later in the evenings on Fridays. The percentage of drivers with high BACs during the later hours on Saturday evenings shows an upward trend since 1986 but is still lower than in 1973.

Table 4 provides a comparison between the three surveys on driver demographic characteristics including gender, ethnicity, and age. The representation of three groups in the national surveys has increased during the last two decades and is exerting some impact on the overall national totals of drinking drivers.

(a) The percentage of females in the weekend nighttime sample of drivers increased from 16.5% in 1973 to 25.5% in 1986 to 30.6% in 1996. The increase from 1973 to 1986 was accompanied by a reduction in the percentage of women with high BACs. However, between 1986 and 1996, the percentage of women with high BACs increased, but not significantly. The combined effect of more women drivers who are also drinking in greater numbers partially accounts for the smaller national decrease in drinking and driving between 1986 and 1996 than between 1973 and 1986.

TABLE 3. COMPARISON OF HIGH BAC DRIVERS IN RELATION TO TIME OF NIGHT AND WEEKEND NIGHT AND TOTAL SAMPLE IN 1973, 1986, AND 1996

	1973 BAC results			1986 BAC results			1996 BAC results		
	Unwtd[1] N	≥0.05 (%)	≥0.10 (%)	Unwtd N	≥0.05 (%)	≥0.10 (%)	Unwtd N	≥0.05 (%)	≥0.10 (%)
Friday									
10 PM – midnight	845	9.5	3.0	750	4.7*	1.6	1,842	4.2	1.0
1 – 3 AM	755	20.6	7.3	648	11.9*	5.0	1,492	13.1	4.0
Saturday									
10 PM – midnight	841	9.5	3.4	833	6.7	2.8	1,865	5.3	2.4
1 – 3 AM	751	21.6	10.1	619	15.0*	5.5*	1,281	16.4	6.7
Total									
All cases	3,192	13.7	5.1	2,850	8.4*	3.2*	6,480	7.7	2.8

* Significantly different at p<.05 from prior survey

[1] Unweighted

TABLE 4. COMPARISON OF HIGH BAC DRIVERS IN RELATION TO DEMOGRAPHIC CHARACTERISTICS IN 1973, 1986, AND 1996

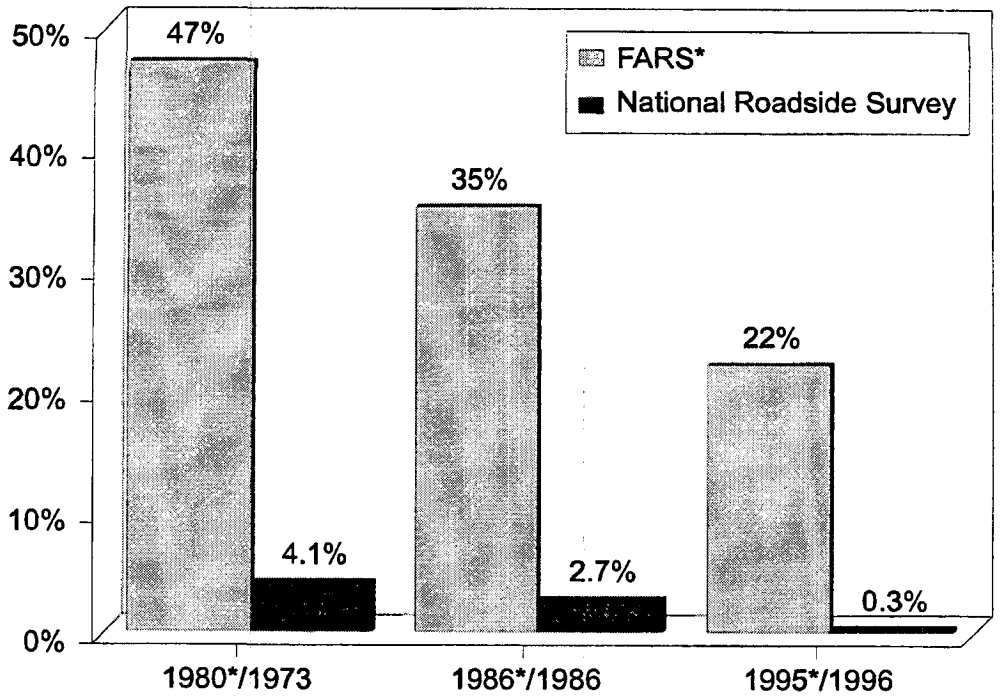
	1973 BAC results			1986 BAC results			1996 BAC results		
	Unwtd N	≥0.05 (%)	≥0.10 (%)	Unwtd N	≥0.05 (%)	≥0.10 (%)	Unwtd N	≥0.05 (%)	≥0.10 (%)
Sex of driver									
Male	2,648	14.7	5.5	2,114	9.9*	3.9	4,229	8.7	3.5
Female	526	8.8	3.0	728	3.9*	1.3	1,984	5.8	1.5
Race/ethnicity									
White									
African American	256	16.5	6.0	328	13.5	5.9	947	9.4	3.6*
Hispanic	43	22.0	3.3	124	13.0	4.4	612	14.9	7.5
Age group of driver									
Age <21	767	10.9	4.1	506	4.6*	2.7	977	2.8	0.3*
Age 21 to 34	1,393	15.4	5.7	1,341	9.9*	3.3*	2,634	11.3	3.8
Age 35 to 44	419	15.9	5.8	497	9.4	4.7	1,215	6.9	3.7
Age > 45	559	12.1	4.1	489	6.8	1.8	1,219	5.2	1.7

*Significantly different at p<.05 from prior survey

(b) The percentage of African American drivers interviewed in the three surveys increased from 8.0% in 1973 to 11.5% in 1986 to 14.6% in 1996; yet, the percentage of drivers with high BACs declined steadily. The percentage of drivers with BACs at or greater than .10 was significantly lower in 1996 than 10 years earlier.

(c) The percentage of Hispanic drivers interviewed in the national surveys increased from 1.3% in 1973 to 4.4% in 1986 to 9.4% in 1996. The percentage of these drivers with BACs of .10 or greater has increased in each survey and is twice as high in 1996 as in 1973. However, because of the relatively few Hispanic drivers in the survey, this increase is not statistically significant.

The steady drop over the last two decades in the percentage of high BACs among fatally injured drivers under age 21 is clearly reflected in the number of high BAC drivers in that age group as shown in Figure 4. There was a significant decline in the percentage of these drivers with BACs of .10 or greater across the three surveys, from 4.1% in 1973 to 2.7% in 1986 to 0.3% in 1996. In contrast, in the last decade, there was no reduction in the percentage of drivers at or greater than .10 BAC in the 21- to 34-age group, which accounts for the largest number of fatalities with high BACs. While the 35- to 44-age and 45-plus-age groups show some evidence of a reduction in the numbers of high BAC drivers in 1996 compared to 1986, these differences are not significant.



*Based on FARS data from the 15 states with good BAC reporting (greater than 80% of fatally injured drivers). 1980 is the first year for which 80% or better test results were available. 1995 is the latest year available.

FIGURE 4. COMPARISON OF THE PERCENTAGE OF DRIVERS UNDER AGE 21 WITH BACS OF .10 OR GREATER ON THE ROAD (FROM NATIONAL SURVEYS) AND IN FATAL CRASHES (NHTSA, 1995)

A logistic regression analysis (Table 5) was conducted to determine the relationship of each of the variables in Tables 3 and 4 to the occurrence of a high (.05 or higher) driver BAC with the effects of the other factors held constant. The variables in Tables 3 and 4 were entered simultaneously into the prediction equation and the results are shown in Table 5, which lists the odds ratios across the survey years. Late-night drivers and males were more likely than early-evening and female drivers to have BACs of .05 or greater in all three surveys. However, while in 1986 men were almost 200% more likely than women to have BACs of .05 or greater, this differential decreased significantly to only 44% more likely in 1996. Saturday night drivers were slightly more likely to have BACs of .05 or greater than Friday night drivers, but this difference was only significant in 1986. African Americans were more likely than Whites in 1986 to have BACs of .05 or greater. However, African American drivers with BACs of .10 or greater decreased significantly between 1986 and 1996, yet still remaining above the level of Whites. Hispanics, on the other hand, were more than 60% more likely than Whites to have BACs of .05 or greater in the last two surveys. Drivers under age 21 tended to be somewhat less likely to have BACs of .05 or greater than middle-aged adults, a trend that became significant in the 1996 survey. In contrast, the high-risk 21- to 34-year age group increased its tendency to have more high BAC drivers over the three surveys with the latest showing an 80% greater likelihood than the 45-and-over group of drivers.

TABLE 5. RESULTS OF LOGISTIC REGRESSION MODELS PREDICTING ODDS OF HAVING BACS OF .05 OR GREATER

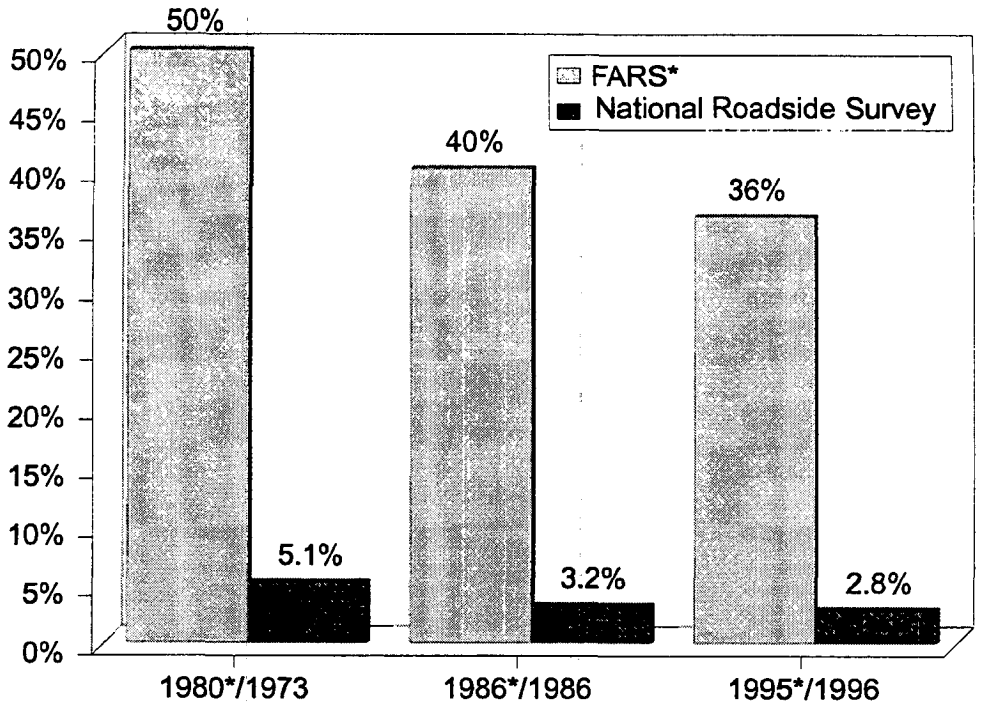
	Odds ratio		
	1973	**1986**	**1996**
Saturday/Friday	1.05	1.34*	1.22
Late/early	2.66*	2.53*	3.35*
Male/female	1.82*	2.72*	1.44[1]
African American/White	1.24	1.81*	0.99
Hispanic/White	0.95	1.65	1.67*
Under 21/45 and over	0.82	0.68	0.39*
21 - 34/45 and over	1.09	1.38	1.82*
35 - 44/45 and over	1.26	1.30	1.09

* Odds ratios significantly different from 1.0 ($p<0.05$)
[1] Odds ratio significantly different from previous survey ($p<0.05$)

DISCUSSION

The 1996 survey resulted in more than 6,000 interviews, twice as many as the two earlier surveys. BAC measures were obtained on 96% of the subjects entering the survey site. BACs on the remaining subjects were imputed using PAS readings. The data were analyzed using the SUDAAN program to correct for correlational relationships between sample cells and logistic regression to control for the relationships between variables. Nonetheless, the 1996 study suffered from some of the limitations encountered in the previous surveys. Only private four-wheel vehicle operators in the 48 contiguous states and only weekend evenings were covered by the 1996 survey. The 12 AM to 1 AM period was not measured to allow the teams to move to new sites. As before, alternative primary sampling units had to be selected in locations where police departments could not support the study.

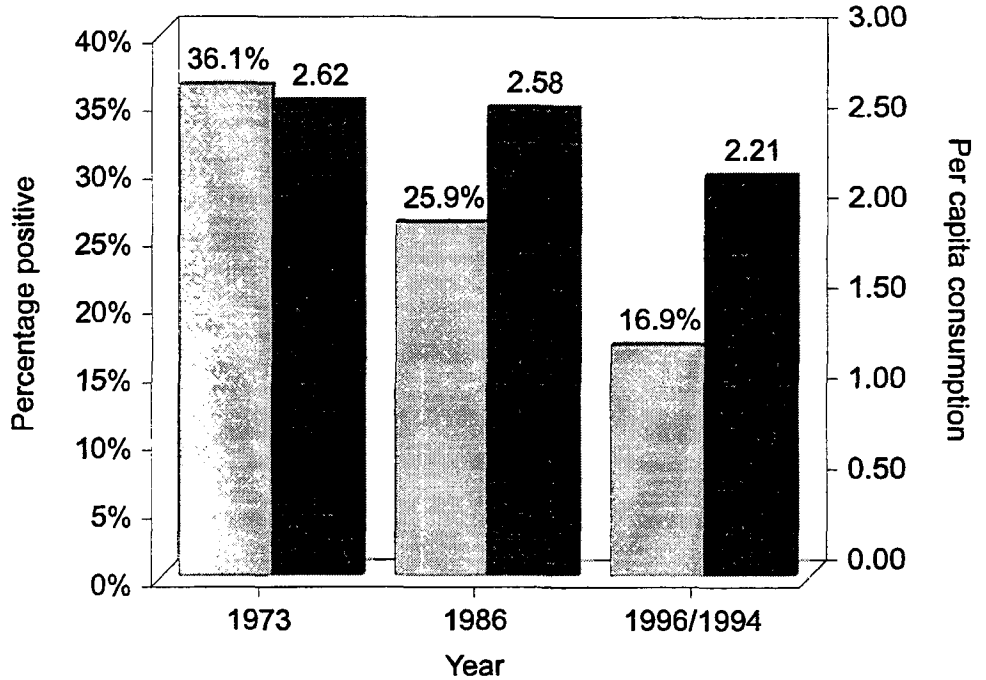
The results demonstrate that the overall percentage of drinking drivers on American roads has declined significantly since 1973. However, there was been no statistically significant reduction in the percentage of drivers at the highest BACs. Nevertheless, since the first survey in 1973, the trend in the percentage of surveyed drivers with BACs of .10 or greater has roughly paralleled the trend in the percentage of fatally injured drivers with BACs of .10 or greater. This comparison is shown in Figure 5.



*Based on FARS data from the 15 states with good BAC reporting (greater than 80% of fatally injured drivers). 1980 is the first year for which 80% or better test results were available. 1995 is the latest year available.

FIGURE 5. COMPARISON OF THE PERCENTAGE OF DRIVERS WITH BACS OF .10 OR GREATER ON THE ROAD (FROM NATIONAL SURVEYS) AND IN FATAL CRASHES (FROM NHTSA, 1995)

The continuing decrease in the overall percentage of drinking drivers appears to represent a change in national norms related to driving after drinking rather than just a general reduction in alcohol consumption. The overall reduction in the percentage of drinking drivers on the road, from 36.1% in 1973 to 16.9% in 1996—a 53% relative decline—can only partly be accounted for by the more modest decline in per capita alcohol consumption in the United States (from 2.62 gallons of ethanol in 1973 to 2.21 in 1994)—a 16% decrease as shown in Figure 6 (Williams, Stinson, Lane, Tunson, & Dufour, 1996).



Source: Williams, G.D., Stinson, F.S., Lane, J.D., Tunson, S.L., Dufour, M.C. *Surveillance report #39: Apparent per capita alcohol consumption: National, state, and regional trends, 1977B94.* Rockville, MD: National Institute on Alcohol Abuse and Alcoholism, Division of Biometry and Epidemiology, Alcohol Epidemiologic Data System; December 1996.

FIGURE 6. PERCENTAGE OF WEEKEND NIGHTTIME DRIVERS WITH POSITIVE BACS ON U.S. ROADS AND APPARENT PER CAPITA ETHANOL CONSUMPTION IN THE UNITED STATES

There are several noteworthy trends in the BAC data among specific categories of drivers. Weekend nighttime drivers under age 21 with BACs of .05 or greater have shown significant declines from the 1973 survey. These results are consistent with the declines in the proportion of underage drivers in fatal crashes with high BACs (Figure 4) and the reduction of 49% in DUI arrest rates for juveniles compared to a 24% reduction for adults between 1986 and 1995 (Snyder, 1997). These trends appear to support the contention that minimum legal drinking age laws implemented in the mid-1980s by those states with lower age limits have been effective in reducing alcohol-related fatalities among youth (Toomey, Rosenfeld, & Wagenaar, 1996). It is possible that the recent trend for states to enact zero tolerance laws (.02 BAC limits) for those under age 21, which have been shown to be effective in reducing alcohol-related crashes (Hingson, Heeren, & Winter, 1994), has contributed to the reductions observed in the 1996 survey.

The lack of change in the percentage of drivers at high BACs in the 21- to 34-year-old age group appears to support the attention given to this issue by groups such as the National Commission Against Drunk Driving and the NHTSA. Alternatively, few programs are directed at females who, as the current results suggest, are driving more and drinking more than in the past. In this 1996 survey, when the BACs of drivers in the under-21 age group were analyzed by gender, females were found to be as likely to be drinking as males. This suggests that, with a new baby boom about to enter adulthood, drinking and driving, which has been primarily a male problem in the past, could become a significant issue for women in the future. These results are consistent with the data reported by Popkin (1993) in her review of factors influencing drinking and driving by women.

The percentage of African American drivers participating in the 1996 national survey was 15.2% compared to 8.1% in the 1973 survey, apparently reflecting an 88% increase in weekend drivers for this ethnic group. During this period, their percentage in the U.S. population increased by only 11%. Happily, during the last decade, this increase in participation in the nighttime driving population has been accompanied by a reduction in drinking and driving that is larger than for the White ethnic group. The increase in nighttime driving may principally reflect the improved economic status of African Americans. The factors producing the relative reduction in drinking before driving are less clear.

Participation in the national roadside survey by Hispanics increased from 1% in 1973 to 10% in 1996, a 90% relative increase. However, these data should be interpreted with caution, because they are based on interviewer observations that are fairly unreliable with respect to ethnicity. Nevertheless, the survey data do make clear that there is no evidence of a decline in drinking and driving in this group. This suggests that studies such as the report funded by the NHTSA (1995) on the Highway Safety Needs of U.S. Hispanic Communities: Issues and Strategies are much needed.

REFERENCES

Cammisa, M.X.; Ferguson, S.A.; Wells, J.K. Laboratory evaluation of PAS III sensor with new pump design. (1996, March). Located at: Insurance Institute for Highway Safety, 1005 N. Glebe Road, Arlington, VA 22201.

Fiorentio, D.; A laboratory study of passive alcohol sensors. Unpublished, available from Southern California Research Institute, Los Angeles, CA; 1997

Hingson, R.; Heeren, T.; Winter, M. Lower legal blood alcohol limits for young drivers. *Public Health Reports*. 109:738-744; 1994.

Lestina, D.C.; Greene, M.; Wells, J.; and Voas, R.B. The 1996 national roadside survey: Sampling procedures and survey methodology. *Evaluation Review* 23 (1): 28-46; 1999.

Lund, A.K.; Wolfe, A.C. Changes in the incidence of alcohol-impaired driving in the United States, 1973-1986; *Journal of Studies on Alcohol,* 52(4); 1991.

Kiger, S.M.; Lestina, D.C.; Lund, A.K. Passive alcohol sensors in law enforcement screening for alcohol-impaired drivers; *Alcohol, Drugs and Driving, 9*(1); 1993.

Klein, T. *A method of estimating posterior BAC distributions for persons involved in fatal accidents.* (DOT HS 077 094). Washington DC: U.S. Department of Transportation; 1986.

NASS/CDS. National accident sampling system/crashworthiness data system: Analytical users manual. Washington, DC: National Highway Traffic Safety Administration; 1995:67-68.

NHTSA. Highway Safety Needs of U.S. Hispanic Communities: Issues and Strategies (Report No. DOT HS 808 373). Washington, DC: National Highway Traffic Safety Administration, 1995:159.

National Highway Traffic Safety Administration. *Fatality Analysis Reporting System (FARS 95).* Washington, DC: U.S. Department of Transportation. 1995.

National Highway Traffic Safety Administration. Amendment of conforming products list of evidential breath test devices, *Federal Register*, 58(179):48705 (17 February Notices). 1993.

Popkin, C.L. A consideration of factors influencing drinking and driving by women,. *Alcohol, Drugs, and Driving.* 9(3-4):197-209; 1993.

Sarndal, C.E.; Swensson, B.; Wretman, J. Model assisted survey sampling. New York: Springer-Verlag; 1992.

SD-400, Lion alcometer 400 series technical brochure. LION Ty Verson Industrial Estate. Wales, United Kingdom; 1995.

Shah, B.V.; Barnwell, B.G.; Bieler, G.S. SUDAAN: Software for analysis of correlated data; Release 6.40; Research Triangle Park, NC: Research Triangle Institute; 1995.

Snyder, H.N. Juvenile arrests for driving under the influence in 1995 near lowest levels in last 20 years. Washington, DC: National Center for Juvenile Justice. June 1997.

Toomey, T.L.; Rosenfeld, C.; Wagenaar, A.C. The Legal Drinking Age: History, Effectiveness, and Ongoing Debate. *Alcohol, Health and Research World,* 20(4):213-218; 1996.

Williams, G.D.; Stinson, F.S.; Lane, J.D.; Tunson, S.L.; Dufour, M.C. Surveillance report #39: Apparent per capita alcohol consumption: National, state, and regional trends, 1977–94. Rockville, MD: National Institute on Alcohol Abuse and Alcoholism, Division of Biometry and Epidemiology, Alcohol Epidemiologic Data System; December 1996.

Wolfe, A.C. 1973 US national roadside breath testing survey: Procedures and results. Ann Arbor, MI: University of Michigan Safety Research Institute; 1974.

Zador, P. L. Alcohol-related relative risk of fatal driver injuries in relation to driver age and sex. *Journal of Studies on Alcohol, 52*(4), 302–310; 1991.

Appendix B

SAMPLING PROCEDURES AND SURVEY METHODOLOGIES FOR THE 1996 SURVEY WITH COMPARISONS TO EARLIER NATIONAL ROADSIDE SURVEYS

Diane C. Lestina
Pacific Institute for Research and Evaluation
Bethesda, MD

Michael Greene
U.S. Consumer Product Safety Commission
Washington, DC 20207

Robert B. Voas
Pacific Institute for Research and Evaluation
Bethesda, MD

JoAnn Wells
Insurance Institute for Highway Safety
Arlington, VA

Contact:
Robert B. Voas, Ph.D.
7315 Wisconsin Avenue
Suite 1300 West
Bethesda, MD 20814

April 16, 1999

AUTHOR'S NOTE: Research for this article was supported by the Insurance Institute for Highway Safety, Arlington, Virginia, and the National Highway Traffic Safety Administration, Washington, DC.

ABSTRACT

This paper describes the multistage sampling system employed in the 1996 national roadside survey and compares it to the sampling methods employed in the two prior surveys in 1973 and 1986. Also described are the data collection procedures at the selected sites, the breath-test devices used to collect blood alcohol concentration (BAC) data, and the methods used to impute BAC values where breath-test measures were not obtained. Overall, almost twice as many (6,298 in 1996 compared to 3,698 in 1973 and 3,043 in 1986) drivers were interviewed in the most recent national survey as in the previous efforts. The procedures implemented in the three surveys are sufficiently similar to permit comparison of these surveys conducted at 10-year intervals.

INTRODUCTION

An important factor in the success of traffic safety program evaluations has been the availability in most industrialized nations of reasonably comprehensive archival data on roadway crashes. To make this incidence data more meaningful, it is necessary to have prevalence data that can be the basis of developing relative risk data. Voluntary roadside breath-test surveys, in which motorists are stopped at random and requested to provide a brief interview and a breath sample to determine their BAC, have been a standard means for gathering such prevalence data for both risk estimation and evaluations of programs directed at reducing alcohol-related crashes.

Since the first such survey was conducted by Holcomb in 1958, roadside surveys have been used for three purposes: (1) to determine the relative risk of crash involvement, (2) to evaluate alcohol safety programs, and (3) to track national changes in drinking and driving.

The most common purpose of roadside surveys is to collect prevalence data for comparison with crash data to develop relative risk curves. The best known of such studies is the classic study by Borkenstein, et al. (1994) in Indiana that surveyed non-crash-involved drivers at the times and places where crashes had occurred. These studies have been recently summarized by the National Highway Traffic Safety Administration (NHTSA, 1992) and by Perrine, Peck, and Fell (1989).

A second application of this survey technique has been for the purpose of evaluating alcohol safety programs (Levy, et al. 1978; Voas & Hause, 1987; Voas, Holder, & Gruenewald, 1997). In these studies, multiple surveys are conducted in the same locations over time to detect changes in the number of drivers at high BACs on the roadways as an outcome measure.

A third application of this technique has been the use of roadside breath-test surveys as a surveillance method for tracking national changes in drinking and driving. The first nationally representative roadside breath-test survey was conducted in 1973 (Wolfe, 1974), followed by a second national survey in 1986 (Lund & Wolfe, 1991). The second survey indicated that the number of drivers over the 0.10% legal limit on the roads on weekend evenings in the United States had

decreased from 4.9% to 3.1% in the 13 years between the two surveys. In the fall of 1996, the Insurance Institute for Highway Safety (IIHS) and NHTSA initiated a third national roadside survey (Voas, et al., in press). A critical feature of surveys of this type, which are intended to track changes over time, is the maintenance of equivalent sampling systems so that the results of successive surveys can be compared.

OVERVIEW OF THE 1996 SAMPLING PLAN

It is obviously impossible to conduct surveys on all the roads in America. Therefore, a sampling system was constructed that was representative of the United States but required interviewing only a few thousand of the over 175 million drivers that were using American roads in 1996. Thus, the current survey and the two prior national roadside surveys were limited to the 48 contiguous states. All three surveys were conducted between 10:00 PM and midnight and between 1:00 AM and 3:00 AM on Friday and Saturday, when heavy drinking is most likely to occur and alcohol-related crashes are most frequent (NHTSA, 1995). Consequently, results from the surveys are based on locations and periods when drinking and driving is most prevalent and, therefore, not typical of all times or roadways in the United States. From a practical standpoint, these national surveys had to limit survey locations to roadways with sufficient traffic to provide enough interviews late at night to justify the expense of employing a survey crew. Thus, counties with populations of less than 20,000 were not surveyed. In counties with larger populations, only roadways with 2,000 to 4,000 average daily traffic counts were included in the survey.

All three national surveys used multistaged samples that were developed to be representative of the 48 contiguous states in the year the data were collected. The first stage of the sample design was the selection of cities, large counties, or groups of counties to be primary sampling units (PSUs) within specific region and population strata. Second, police jurisdictions (PJs) within each of the PSUs were selected and invited to participate in the survey. The third step was to select survey sites within the geographical area of the selected PJs by placing a grid over the area and randomly selecting cells where survey sites would be located. Finally, drivers to be interviewed were selected at random from the traffic passing the survey site.

These sampling procedures were followed to insure that the probability of selecting a PSU, a PJ survey location, and a driver was known at each stage in the sample design. Knowing these probabilities allowed the computation of the probability that each driver would be interviewed in the survey. This was done by multiplying the sampling probabilities at each of the four stages to obtain the final overall probability of being sampled. The weight given to each case in the final totals (sampling weight) was then computed as the inverse of the sampling probability—that is, data from drivers who were unlikely to be interviewed based on the sampling procedure used were given more weight than data from drivers who were more likely to be interviewed. This insured that the basic requirement of the sampling theory—that every driver had an equal chance of being interviewed—was met by adjusting for the biases inherent in the selection of locations within the

sampling frame. This multistage sampling system provided unbiased estimates of national totals (Sarndal, Swensson, & Wretman, 1992).

The major barrier to implementing this staged sampling scheme was obtaining police department support for the survey. In some localities, city attorneys or the police believed that legal limitations to stopping vehicles or potential liability prevented their participation in the surveys. In other cases, police departments reported that they lacked the personnel to support the effort. This resulted in substitutions for initially selected PSUs and PJs where cooperation was not available in all three national surveys. The effect of these departures from the original structure of the sample was minimized by insuring that the substitute was selected from the same geographical region and population strata. Because police department support was not available, substitutions were made as follows: five PSUs for the 1973 survey, nine PSUs for the 1986 survey, and five PSUs for the current survey.

Each of the three national surveys used a slightly different procedure for developing the first two levels—counties and police departments—of the four-stage sample. The last two stages—roadways and drivers—were selected in the same manner. The first stage of the sampling plan for the 1973 survey was to select 24 PSUs from four geographical regions of the country, within counties, based on three population criteria. The 1973 survey selected PSUs at random from a set of standard metropolitan statistical areas (SMSAs) established by the U.S. Bureau of the Census. The 1986 survey plan began with the same set of PSUs as were used in the 1973 survey. Thus, these first two surveys were based on selecting sites based on population.

1996 Sampling Plan

Selection of PSUs

The 1996 survey used the PSUs that were used in the National Automotive Sampling System (NASS/CDS 1995), which consists of two parts: (1) the General Estimates System (GES) (NHTSA, 1991) collects data on an annual sample of approximately 54,000 police-reported motor vehicle traffic crashes occurring in 60 PSUs across the United States; and (2) the Crashworthiness Data System (CDS) collects detailed information on an annual sample of approximately 5,000 traffic crashes involving at least one vehicle that is towed from the crash scene in 24 PSUs across the nation.

The present survey began with the 24 PSUs employed by the CDS (NASS/CDS, 1995). The CDS sampling frame was used in the present research for two reasons: (1) use of the CDS offered the possibility of weighting the sample by crash frequency rather than population which has the advantage of producing a smaller sampling variance (NASS/CDS, 1995) and (2) use of the CDS list of police jurisdictions provided easier access to police departments because they were already cooperating with the NHTSA. The multistage sampling system used in all three surveys produces a valid comparable estimate of the national level of drinking and driving as long as the sampling plan is carefully implemented.

Selection of Counties

In the first two stages of the sample, counties and police departments were selected using a probability proportional to size (PPS) scheme, where the number of fatal and serious injury crashes served as the measure of size. The survey used the NASS/CDS (1995) sample for parts of the first two stages. Initially, the 24 PSUs that were selected from the CDS came from a frame of 1,195 PSUs, which then formed the set of selected PSUs for the National Breath-Test Survey. The sample selection probability was then exactly the same as that used in NASS/CDS (1995). During the course of the survey, five PSUs had to be replaced. The first level of PSU replacement was from the NASS/GES sample, which is a superset of the NASS/CDS sample containing 60 PSUs. Simple random sampling was used to select replacement PSUs from among the already selected GES PSUs. Since GES PSUs (like CDS PSUs) used probability proportional to size (PPS), simple random sampling preserved the overall PPS structure and the sampling probabilities only changed by a constant. When the inventory of GES PSUs was exhausted in a particular stratum, the next level of PSU replacement came from the 1,195 frame. In this case, the sampling mechanism was PPS as applied to the selection of the 60 GES PSUs.

Selection of Police Jurisdictions

The same general procedure as in the two previous national surveys was employed in selecting and recruiting police departments. Initially, using the CDS frame, departments were selected from those chosen for the CDS using simple random sampling. This preserved the underlying PPS scheme. Police departments electing not to participate were replaced by other departments from the same PSU in the CDS pool and then by other departments in the GES frame. Replacements were selected from participating CDS departments using simple random sampling. Non-CDS departments in the GES were selected using PPS. Departments in PSUs outside the GES sample (see above) were selected either with PPS or with "certainty" where the PJ and the PSU were co-existent (e.g., Philadelphia).

Several police departments in the CDS and GES were not considered. First, departments with fewer than 20 sworn officers were excluded because they would be unlikely to have the resources to provide officers for the survey. Second, departments were excluded where it would be difficult to install survey sites (for example, departments patrolling Native American reservations, airports, hospitals, and harbor jurisdictions). Except for California, state police units were also excluded because their jurisdictions were limited to interstate and arterial highways. Because vehicles could not be safely stopped at these locations they would be inappropriate for survey sites.

In June 1996, 54 PJs were contacted to cover the original 24 PSUs. Subsequently, an additional 48 letters were sent to PJs to cover the 5 substitute PSUs and the PSUs in which originally selected departments were unwilling to participate. In all, 39 PJs did not participate, 22 due to legal or liability issues and 17 because of personnel shortages. A total of 43 PJs agreed to assist in the survey procedure, and 2 other departments agreed to allow the survey to be attached to a sobriety checkpoint. Eighteen of the 102 PJs initially contacted were not followed

up because they were not needed. The PSUs and police jurisdictions participating in the survey are shown in Table 1.

TABLE 1. 1996 NATIONAL ROADSIDE SURVEY SITES

Northeast	South	West	Midwest
NEW JERSEY **Ocean County** Lakewood PD–4 sites Lacey TWP–4 sites	**ALABAMA** **Tuscaloose** Tuscaloosa PD–8 sites	**ARIZONA** **Gila County** Gila County Sheriff–9 sites **Yuma, La Paz County** Yuma PD–6 sites Yuma County Sheriff–4 sites La Paz County Sheriff–2 sites	**ILLINOIS** **Cook County** Cicero PD–4 sites Cook County Sheriff–1 site Checkpoint
NEW YORK **Brooklyn** Precinct 72–5 sites Precinct 60–6 sites **Ulster County** Ulster County Sheriff–8 sites New Paltz Town Police–4 sites	**FLORIDA** **Fort Lauderdale** Hollywood PD–6 sites Fort Lauderdale PD–6 sites	**CALIFORNIA** **Los Angeles** LAPD–8 sites **San Diego** CHP–San Diego–2 sites Checkpoints Fri & Sat nights	**INDIANA** **Madison County** Madison County Sheriff–5 sites
PENNSYLVANIA **Allegany County** Ross TWP–4 sites Penn Hills–4 sites **Montgomery County** Pottstown–4 sites Montgomery TWP–4 sites Whitpaint TWP–4 sites **Philadelphia** Philadelphia PD–8 sites	**MARYLAND** **Charles, PG County** Laurel PD–4 sites Takoma Park PD–4 sites Greenbelt PD–4 sites **NORTH CAROLINA** **Greensboro** Greensboro PD–8 sites **Wake County** Cary PD–6 sites Garner PD–3 sites Morrisville PD–2 sites **TENNESSEE** **Knox County** Knox County Sheriff–4 sites	**COLORADO** **Jefferson County** Wheat Ridge–4 sites Westminster–6 sites **WASHINGTON** **King County** Des Moines PD–2 sites Kent PD–4 sites Renton PD–6 sites	**MICHIGAN** **Genessee County** Flint PD–4 sites Mt. Morris–2 sites Flint TWP–2 sites **Muskegon County** Muskegon County Sheriff–8 sites Norton Shores–2 sites **NEBRASKA** **Douglas County** Omaha PD–8 sites **OHIO** **Columbus** Franklin County Sheriff–8 sites

TWP = Thruway police

Selection of Survey Locations

Once police departments had been selected, survey locations were determined in conjunction with the departments. In urban and suburban regions, a map of the area was divided into squares of approximately 1-square mile each. Squares containing few or no road segments such as fields or parks were not included in the sampling frame. From those available, squares were selected, using simple random sampling, as possible sites for a survey location with no more than one survey location permitted in a square. In rural regions with few roads, 1-mile lengths of major roads were marked off. From these available segments, those utilized for survey sites were randomly selected, with no more than one site per segment. A few

were selected at random. Recording the number of squares or road segments from which the sites sampled in the survey were taken allowed weighting the final sample based on the ratio of the number of available sampling areas to the number of sites actually used.

In both cases, with squares or road segments, the survey team was instructed to find a safe and effective site within the particular location. To be considered safe, the site had to provide enough viewing distance of the roadway to permit the officer to signal oncoming vehicles to stop. This distance obviously varied with the typical speed of the traffic on the roadway. The best locations were lighted, off-road parking areas into which selected drivers could be directed. In rural areas, however, the interviews had to be conducted at the side of the road. In all cases, it was necessary to have police department approval of the survey site.

Selection of Drivers

At the sites, drivers were selected from the traffic flow by an officer, who would signal the next car approaching the survey site after an interviewer had completed a survey. This procedure is typically used in roadside surveys and results in a random selection of eligible vehicles that is not biased toward any particular class of driver. To insure unbiased selection of the first vehicle at each interview site, the third vehicle passing the site after initiation of the survey was chosen by an officer for the first interview. Police officers were provided with counters to record all vehicles passing the site during an interview period so that driver selection probabilities could be estimated. In the 1973 and 1986 surveys, data were initially weighted based on both the traffic volume and average traffic speed (Wolfe, 1974; Lund & Wolfe, 1991). The use of average speed at the survey sites is intended to correct for the fact that motorists driving at higher average speeds were more likely to be selected in the survey. However, the correction was found to have only a minor effect. In any case, the desire was to estimate the probability of meeting a motorist at a given BAC, rather than record the absolute number of such motorists on the highways. The speed correction was not applied in the Lund and Wolfe (1991) report on the first two surveys or in the analysis of the 1996 survey. Only the traffic counts have been used in the weighting of data in the 1996 survey and in comparisons across surveys.

Imputation for First- and Second-Stage Unit Refusals

At the conclusion of the survey, sample selection probabilities were recalculated for both PSUs and police departments by removing units from the frame because they refused to participate in the survey or state laws about roadside checkpoints made it unlikely that they would have participated had they been contacted. In a sense, then, the survey results do not apply to the units that refused to participate.

A second correction was made for one urban PSU, where the survey site was only operated from 10:00 PM to midnight on both nights. Since the previous surveys showed that the proportion of high-level BAC drivers is greater between 1:00 AM and 3:00 AM than between 10:00 PM and midnight, failure to correct for this problem would produce a lower estimate of the number of drivers with high BACs.

Imputation was accomplished by estimating the number of drivers that would have passed the site and their BAC distribution using (1) the early evening totals at this PSU and (2) the traffic counts and BAC distribution of the other urban PSU on the same night in the same geographic region. This calculation was used to adjust the sampling weights to compensate for the missing hours.

SURVEY PROCEDURES

The roadside survey procedures implemented in 1996 followed those used in the previous two national surveys as closely as possible. Three survey teams of three civilian interviewers each, one of whom was appointed the team leader, were selected and trained during the last week of August 1996. Each team was assigned a set of PSUs—roughly based on geographical location, in the east, midwest, and far west regions of the country—as shown in Table 2. Surveys were conducted between 10:00 PM and midnight and between 1:00 AM and 3:00 AM on Fridays and Saturdays beginning with Friday, 6 September 1996, and concluding 10 weeks later on Saturday, 9 November.

TABLE 2. 1996 NATIONAL ROADSIDE SURVEY DATES AND LOCATIONS

Weekend	Team 1	Team 2	Team 3
9/6 – 9/8	Muskegon, MI	Ulster County, NY	Gila County, AZ
9/13 – 9/15	Genessee, MI	Allegheny County, PA	Kings County, WA
9/20 – 9/22	—	Madison County, IN	Jefferson County, CO
9/27 – 9/29	Brooklyn, NY	Columbus, OH	Omaha, NE
10/4 – 10/6	Ocean, NJ	Montgomery, PA	—
10/11 – 10/13	Philadelphia, PA	Prince George's County, MD	—
10/18 – 10/20	Knoxville, TN	Wake County, NC	Yuma, AZ
10/25 – 10/28	Tuscaloosa, AL	Fort Lauderdale, FL	San Diego, CA
11/1 – 11/3	Cook County, IL	—	Los Angeles, CA
11/8 – 11/10	Greensboro, NC	—	—

Team leaders arrived at the PSU on the Thursday before the survey and visited the proposed survey sites with the liaison officer from the cooperating police department. The other two team members arrived on Friday in time to meet with officers before departing for the survey sites. An effort was made to identify three different locations for each of the 2 survey periods on Friday and Saturday nights for a total of 12 sites in each PSU. Some departments were not able to supply three officers; in those localities, only two locations were surveyed during each period. In San Diego and Cook County, where the surveys were conducted as part of checkpoint operations, only one location was used each night.

Once at the site, an officer positioned the police vehicle with its overhead lights flashing so that it could be seen by traffic approaching the site. Also, the vehicle's headlights illuminated the officer. The interviewers worked in off-road parking lots; although, in some cases, the interviews had to be conducted at the side

of the road as illustrated in Figure 1. When ready, the interviewer signaled the officer who then flagged down the next vehicle that could be safely stopped and directed the driver to the interview site. Motorcycles and commercial vehicles were excluded from the survey. Commercial vehicles included buses and large trucks and the occasional pizza delivery or other delivery vehicle when clearly marked by an external sign. Pick up trucks were included among the passenger vehicles to be included in the survey. Motorcycles are commonly excluded from roadside surveys because it is difficult to provide an alternate operator if the participant has a BAC over .05. Commercial vehicles are excluded because of the economic consequences of time lost while the driver is participating in the survey, results in low participation by these operators.

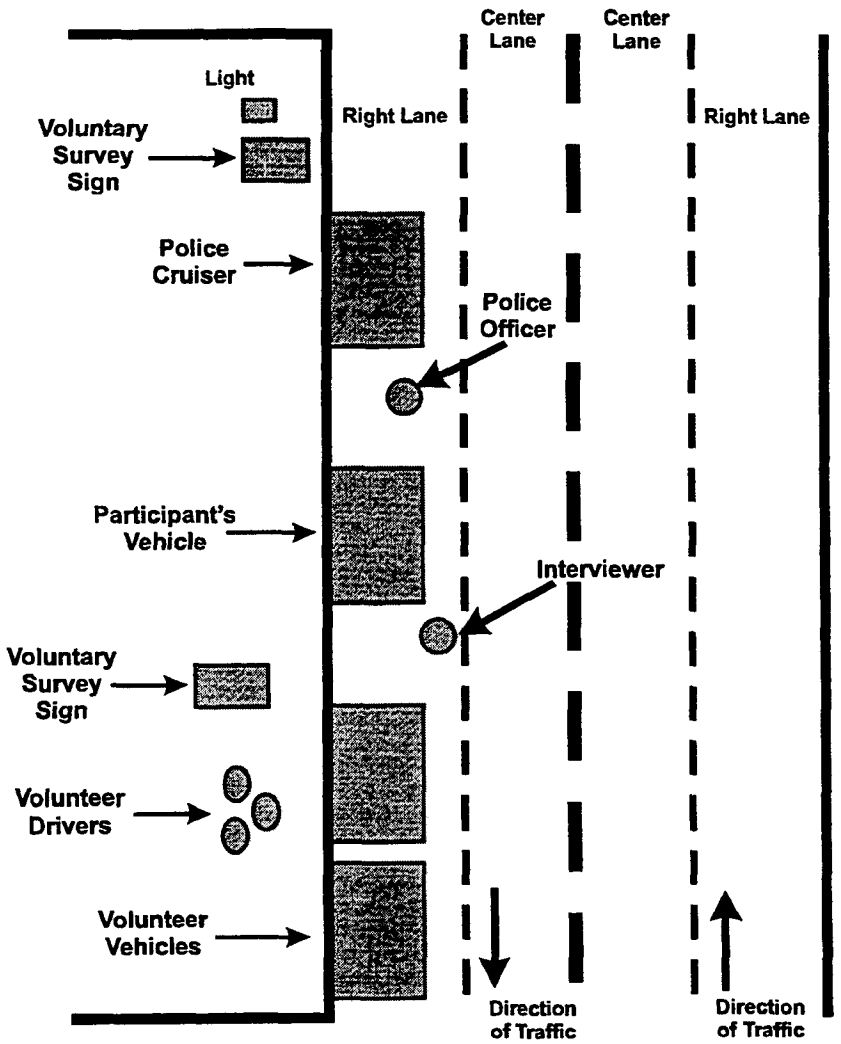


FIGURE 1. EXAMPLE OF A SURVEY SITE ON A FOUR-LANE ROAD

Once the motorist came to a safe stop, the interviewer approached, explained that the survey was voluntary, and obtained informed consent for a brief interview. The interviewee answered 15 questions covering topics such as ethnicity, annual mileage, the origin and destination of the trip, drinking, drinking and driving, and whether the respondent was acting as a designated driver. In addition, the interviewer recorded his or her observations of the number of passengers, use of a safety belt by the driver, and the gender of the driver. Passive sensor and

preliminary breath samples were also obtained. The average time with each motorist was approximately 5 minutes. Interviewers, equipped with a mobile phone, assisted drivers with BACs above 0.05 in obtaining a ride home by taxi or from a friend if a sober passenger was not available to drive. At some locations, local volunteers provided transportation for those at or above 0.05 BAC.

Surveys at checkpoints. In two locations (San Diego, CA, and Cook County, IL), the survey had to be conducted as part of a sobriety checkpoint. In this type of operation, rather than moving from one site to another between midnight and 1 AM, only one location was used on each night. All three interviewers worked at the site, surveying motorists after they had completed their interviews with the police officers.

Two additional personnel were used in these operations. One person stood at the head of the checkpoint and placed a card under the windshield wiper of a car selected for a survey whenever a signal was sent that an interviewer was ready for another motorist. This insured that the same random selection process was used at checkpoint sites as at regular survey sites. The second person worked with the police at the checkpoint to ensure that, if the police detained and breath tested one of the selected motorists, the results of the test were obtained for the survey.

The principal threat to the randomness of this selection procedure was that the checkpoints involved a number of police vehicles, rather than just one, making them visible from a farther distance on the roadway. This may have allowed some high BAC motorists to become aware of the checkpoint, thus giving them the opportunity to turn off the road before reaching the survey site. Another potential threat to the randomness of data collected at checkpoints is that checkpoint locations are chosen by the police, generally on the basis of the number of alcohol-related crashes or DWI arrests. Therefore, they do not represent a random set of roadway locations.

BREATH ALCOHOL MEASUREMENTS

Two breath alcohol measuring devices were employed in the 1996 survey: the CMI Inc. SD-400 handheld preliminary test device and the Public Services Technologies, Inc. PAS III passive sensor flashlight. The SD-400 employs a disposable mouth piece into which an individual blows until the unit automatically samples the end expired air, using a fuel cell alcohol detector. This unit has been tested by the NHTSA laboratory in Cambridge, Massachusetts, and approved for placement on its Conforming Products List for Evidential Breath Testers (NHTSA, 1993). Its accuracy is ± 0.005 at a BAC of 0.020. Because some drivers are unable to provide a sufficient flow of air to provide a valid sample for the SD-400, and others refuse to provide a breath sample, the PAS III unit was used to provide an estimate of the driver's BAC. The PAS III is a standard police officer's flashlight into which has been integrated a small pump and a fuel cell sensor like the one used in the SD-400 (Kiger, Lestina, & Lund, 1993). When activated, the pump operates for 5 seconds drawing air from 6 to 8 inches in front of an individual's face. The approximate BAC is indicated on a nine light scale on the instrument. Properly employed (that is, taking the sample while the person is talking or exhaling), this

sensing device can produce values that, in the 1996 survey, correlated at about the r = .70 level with the SD-400 measure (see Cammisa, Ferguson, & Wells, 1996 and Fiorentio, 1997 for laboratory evaluations of the PAS III device).

To insure that random samples of motorists were selected for the survey, it was necessary to bring the next available vehicle into the survey site when an interviewer was ready for the next respondent. In practice, a few of the selected motorists were missed because they turned away from the site; the officer was unable to signal them in time; or, having spoken with the motorist, the officer allowed the individual to proceed without entering the site. These cases were not reported in the 1973 survey, but the numbers not entering the survey site for the 1986 and 1996 surveys are shown in Table 3. The weighting of the data in the analysis of the survey insures that the motorists selected, but not entering the site, are imputed to have the same distribution of BAC values as those interviewed and tested at the same site.

Once the motorist entered the site, he or she was given an opportunity to become a volunteer interviewee and to provide a breath test. The number of interviews and breath tests provided by these motorists in each of the national surveys is shown in Table 3. As can be seen, the percentage of drivers providing a valid breath measurement has increased across the three surveys. In 1996, of the 270 drivers entering the survey site who were not tested, 74 agreed to blow into the device but were not able to produce enough air to provide a valid measure, and 196 refused to provide a sample.

TABLE 3. DRIVERS ENTERING THE SURVEY SITES

	1973	1986	1996
Selected	Not reported	3260	6480
Did not enter site	—	217	182
Stopped and entered site	3698	3043	6298
Entered site and interviewed	3353 (90.7%)	2971 (97.6%)	6045 (96.0%)
Entered site, valid breath sample	3192 (86.3%)	2850 (93.7%)	6028 (95.7%)
Entered site, no breath sample	506 (13.7%)	193 (6.3%)	270 (4.3%)

Table 4 presents the Passive Alcohol Sensor (PAS) scores for three groups of drivers: 6,028 drivers with valid BAC tests, 196 drivers who refused the BAC test, and 74 drivers who were unable to provide a valid breath-test sample. As can be seen, there is a tendency for those who refused, and those who claimed to be unable to produce a sample, to have a higher distribution of PAS scores than those who provided a valid sample (x^2=25.52, $p<.000$). This is in line with the experience of the other national surveys where those who refused the breath test were estimated to have higher BACs (Wolfe, 1974; Lund & Wolfe, 1991).

A limitation in all roadside surveys is that individuals who refuse to be tested are likely to have higher BACs than those who agree to be tested. This is confirmed both by the current data in Table 4 and the data in Table 5 on the two previous national roadside surveys. In the 1973 and 1986 surveys, the interviewers were

instructed to classify respondents into one of three classes: the driver had been drinking a lot, a little, or not at all. In the 1986 survey, the interviewers' classification of respondents into these three categories was assisted by using an earlier model of the passive sensor that was used in the present survey. As shown in table 5, those not tested were more likely to be voted as drinking by the interviewers The 1996 survey was the first case in which estimates for drivers not tested were developed entirely by objective means.

TABLE 4. DISTRIBUTION OF PASSIVE SENSOR READINGS BY SD 400 BREATH-TEST CATEGORY UNWEIGHTED PERCENTAGES, 1996

		No PAS Measure	PAS Readings								Total
			0	1	2	3	4	5	6	7+	
Agreed to SD-400 test*	N	628	4781	162	127	95	93	63	34	45	6028
	% of PAS Readings		88.5	3.0	2.4	1.8	1.7	1.2	0.6	0.8	100
Refused SD-400 test	N	95	76	5	8	7	2	2	1	0	196
	% of PAS Readings		75.2	5.0	7.9	6.9	2.0	2.0	1.0	0.0	100
Unable to provide SD-400 sample	N	30	35	1	1	1	3	2	0	1	74
	% of PAS Readings		79.5	2.3	2.3	2.3	6.8	4.5	0.0	2.3	100

* X5 for difference between agreed and refused + unable = 25.52, pD.000

TABLE 5. COMPARISON OF THE INTERVIEWER'S ESTIMATE OF DRINKING FOR THOSE WHO AGREED AND THOSE WHO REFUSED THE BREATH TEST IN THE TWO PREVIOUS NATIONAL SURVEYS

Year			No estimate	Not drinking	Drinking a little	Drinking a lot	Difference*
1973	Agreed to test	N % of estimates	54	2269 71.1	822 25.8	47 1.5	X5 = 45.81
	No test	N % of estimates	83	263 52.0	135 26.7	25 4.9	P<.000
1986	Agreed to test	N % of estimates	·534	1795 63.0	476 16.7	45 1.6	X5 = 30.14
	No test	N % of estimates	49	83 43.0	57 29.5	4 2.1	P<.000

* Difference between test and no test for cases with an estimate

Based on the relationship demonstrated between the passive sensor and the SD-400 breath-test reading for the 5,400 (6,028 total minus 628 without passive sensor or SD-400 readings) cases in which both measures were available (line 1, Table 4), an estimate was made of the BAC for each of the interviewees in lines 2 and 3, where only the passive sensor measure was available.

For those drivers who provided both an active sensor (breath-test) reading and a passive sensor reading, it was possible to estimate the probability distribution of the active sensor reading, conditional on the value of the passive sensor reading. For example, of the people with passive sensor readings of 1 bar, 32% had an active sensor reading between 0 and 0.004 BAC, 19% between 0.005 and 0.019, 33% between 0.020 and 0.049 BAC, and the rest had readings over 0.05 BAC. Using these estimates, BAC readings were assigned to individuals who provided only a passive sensor reading. Such people contributed fractional BAC frequency counts. For example, a person with a 1-bar PAS reading but no active sensor reading would be equivalent to 0.32 people with a BAC between 0 and 0.004, 0.19 people between 0.005 and 0.019, 0.33 people between 0.020 and 0.49 BAC, etc. This procedure was used for refusers and those unable to provide breath samples when passive sensor readings were available.

For about half the people who did not provide breath samples, passive sensor readings were also not obtained. For such people, the overall BAC distribution was computed separately for the 196 refusers and the 74 unable to provide breath samples, using the imputation procedure described in the previous paragraph. These individuals were then assigned the appropriate marginal BAC distribution.

Thus, these BAC imputations were based on the single variable of the passive sensor readings. It might be argued that more accurate imputations might have been produced by using all of the measures in the survey with a correlation with the drivers BAC to impute the SD-400 values. However, since the SD-400 values were to serve as the primary dependent variable in most of the analyzes of the roadside data, it appeared undesirable to contaminate the BAC measure by using such variables as age and gender to impute this measure. It should also be noted that the generation of a single imputation value has the effect of reducing the variance of the SD-400 measure (Heitjan & Little, 1991). However, since less than 5% of the SD-400 measures were imputed, it was judged that the reduction in the overall variance would not be significant.

For the last category of drivers (namely, those 182 who did not enter the survey area), there was no reason to believe that their BAC would be higher or lower than average for the particular site. These people were then assigned the average BAC distribution for the site. This can be shown to be mathematically equivalent to removing such people from the number sampled when producing a site estimate weighted for traffic.

The distributions for the 6,028 cases for which actual BAC measures were available are shown on the top line of Table 6, while the distribution of the estimated BACs for the 270 cases for which BAC was not available is shown on the second line. Finally, the combined distribution of 6,298 drivers entering the survey sites is shown on the bottom line of the table.

TABLE 6. BACs FOR MEASURED, IMPUTED, AND COMBINED GROUPS, 1996

		.000	.005-.019	.020-.049	.050-.079	.080-.099	.100-.149	≥.015
Measured BACs	N=6028	4872	261	380	220	103	142	50
	%	80.8	4.3	6.3	3.6	1.7	2.4	0.8
Imputed from PAS	N=270	195	12	24	17	8	11	3
	%	72.2	4.7	8.9	6.3	2.8	4.0	1.1
Combined	N=6298	5067	278	404	237	111	153	53
	%	80.4	4.3	6.4	3.8	1.8	2.4	0.8

ANALYTICAL PROCEDURES

Sample estimates for the percentages of drivers at various BAC levels were derived by using the counts and weights described in the preceding section. Sample variances were estimated on the basis of the sample design using the SUDAAN program (Shah, Barnwell, & Bieler, 1995) with the WR design option. When measures are collected based on a constructed, multistage sampling system (as is the case for all three national surveys), the variances derived will be an underestimate unless they are corrected for the clustering of the samples in the cells of the design. The SUDAAN program corrects the variances of the measures for this clustering effect. Comparisons with the 1973 and 1986 surveys were conducted by entering the data from those investigations into the SUDAAN program. Based on the comparable variance estimates generated by this process, a multifactor logistic regression employing odds ratios was conducted to determine the measures associated with being a driver at or above a BAC of 0.05 and how they changed across the three surveys when the influence of other variables was controlled.

SUMMARY

The procedures described in this report illustrate some of the limitations in the collection of roadside survey data applicable to the nation as a whole. In the past, resources have precluded the collection of data from the states of Alaska and Hawaii and counties with populations of less than 20,000. Due to resource limitations, data collection has also been limited to weekend evenings and to roadways with sufficient nighttime traffic to provide a respondent approximately every 5 minutes—generally a daily traffic count of 2,000 to 4,000.

In 1973, sobriety checkpoints were rare. The public was less sensitized to the drinking-and-driving problem and therefore less concerned with being stopped for DWI. The police, in turn, were less concerned about the constitutionality of random stops. This made obtaining the cooperation of the police to direct vehicles off the road into an interview site was easier in 1973 than in 1986 and 1996. In the later national surveys, police participation became more difficult to obtain because of the concern with liability issues and the formal requirements placed on checkpoint operations that some departments interpreted as precluding random stopping of motorists outside of a full checkpoint program. This, plus resource shortages,

resulted in several departments refusing to participate in the research, requiring substitutes in the original research design.

Despite these limitations, the three surveys appear to have been sufficiently well controlled to provide a reasonable basis for following the trend in drinking and driving in the United States over the last two decades. The changes in driver BACs over that period seem in line with the reductions in alcohol-related crashes over the last two decades. The basic method described in this article appears to provide the means to continue tracking the level of drinking and driving in the United States into the first decade of the third millennium.

REFERENCES

Borkenstein, R.F., R.F. Crowther, R.P. Shumate, W.B. Ziel, and R. Zylman. 1994. The role of the drinking driver in traffic accidents (The Grand Rapids Study). *Blutalkohol* II (1):1-132.

Cammisa, M.X., S.A. Ferguson, and J.K. Wells. 1996. March Laboratory evaluation of PAS III sensor with new pump design. Located at: Insurance Institute for Highway Safety, 1005 N. Glebe Road, Arlington, VA 22201.

Fiorentio, D. 1997. A laboratory study of passive alcohol sensors. Unpublished, available from Southern California Research Institute, Los Angeles, CA.

Heitjan, D. F., and R.J.A. Little. 1991. Multiple imputation for the Fatal Accident Reporting System. *Applied Statistics* 40(1):13-29.

Holcomb, R.L. 1958. Alcohol in Relation to Traffic Accidents. *JAMA* 111:1076

Kiger, S.M., D.C. Lestina, and A.K. Lund. 1993. Passive alcohol sensors in law enforcement screening for alcohol-impaired drivers. *Alcohol, Drugs and Driving 9*(1):7-18.

Levy, P., R. Voas, P. Johnson, and T.M. Klein. 1978. An evaluation of the Department of Transportation's alcohol safety action projects. *Journal of Safety Research* 10(4):162-176.

Lund, A.K., and A.C. Wolfe. 1991. Changes in the incidence of alcohol-impaired driving in the United States, 1973-1986. *Journal of Studies on Alcohol* 52(4).

NASS/CDS. 1995. *National Accident Sampling System / Crashworthiness Data System: Analytical Users Manual.* Washington, DC: National Highway Traffic Safety Administration. (pp. 67-68).

National Highway Traffic Safety Administration. 1995. *Fatality Analysis Reporting System (FARS 95).* Washington, DC: U.S. Department of Transportation.

National Highway Traffic Safety Administration. 1993. Highway safety programs; model specifications for devices to measure breath alcohol. (17 September Notices). *Federal Register* 58(179):48705.

National Highway Traffic Safety Administration. 1992. *Driving under the influence: A report to Congress on Alcohol Limits.* Washington, DC: U.S. Department of Transportation, National Highway Safety Administration.

National Highway Traffic Safety Administration. November 1991. *General Estimates System, 1990: A review of information on police-reported traffic crashes in the United States.* Washington, DC: National Highway Traffic Safety Administration. DOT HS 807 781.

Perrine, M. W., R. C. Peck, and J. C. Fell. 1989. Epidemiologic perspectives on drunken driving. In *Surgeon General's Workshop on Drunk Driving: Background Papers*, edited by U.S. Public Health Service Office of the Surgeon General, 35-76. Washington, DC: U.S. Department of Health and Human Services.

Sarndal, C.E., B. Swensson, and J. Wretman. 1992. *Model assisted survey sampling.* New York: Springer-Verlag.

Shah, C.E., B.G. Barnwell, and G.S. Bieler. 1995. *SUDAAN: Software for analysis of correlated data.* Research Triangle Park, NC: Research Triangle Institute. Release 6.40.

Voas, R.B., and J.M. Hause. 1987. Deterring the Drinking Driver: The Stockton Experience. *Accident Analysis and Prevention* 19(2):81-90.

Voas, R.B., H.D. Holder, and P.J. Gruenewald. 1997. The effect of drinking and driving interventions on alcohol-involved traffic crashes within a comprehensive community trial. *Addiction* 92 (Supp. 2):221.

Voas, R. B., Wells, J., Lestina, D., Williams, A., & Greene, M. (1998). Drinking and driving in the United States: The 1996 National Roadside Survey. *Accident Analysis and Prevention, 30*(2), 267-275.

Wolfe, A.C. 1974. *1973 U.S. national roadside breathtesting survey: procedures and results.* Ann Arbor, MI: University of Michigan Safety Research Institute.

DOT HS 809 019
January 2000

NHTSA
People Saving People
www.nhtsa.dot.gov