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Predicting DUI Recidivism
Volume 1
Blood Alcohol Concentration and Driver Record Factors

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This study examined the relationship between BAC at arrest, driving history, and other demographic factors, and the 1-year post-arrest probability of recidivism for DUI convictees. BAC-only prediction models, complex prediction models involving many factors found on the driver record, and simple prediction models containing two or three factors were developed. All models found a third degree or cubic relationship between BAC and recidivism, and showed recidivism to be high at a BAC of 0.00%, decreasing down to a BAC of about 0.09%, increasing to a BAC of about 0.29%, and then decreasing again to a BAC of 0.35%+. High rates of recidivism at high BACs suggest alcohol dependency, while at low BACs other impairing substances are likely to be involved. The mean rate of DUI recidivism for offenders who refused to be tested for alcohol was the same as the mean rate for BAC-tested offenders who had prior DUIs at the time of the arrest.

The probability of DUI recidivism predicted by a simple model using BAC, prior 2-year total convictions, and offender level could be used by presentence investigators, judges, or in administrative settings to determine appropriate sanctions, treatment program assignment, or other remedial measures. The findings support the notion that first offenders with high BAC levels and/or several prior 2-year total convictions are at as high a risk of recidivating as repeat offenders, and might therefore benefit from similar sanctions and/or remedial treatment. The findings also support viewing DUI arrestees with very low BACs as probable drug users with relatively high probabilities of recidivating.

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PREFACE

This report is the first volume of a two volume report entitled *Predicting DUI Recidivism*. The report is issued as an internal monograph of the Department of Motor Vehicles' Research and Development Section. The opinions, findings, and conclusions expressed in the report are those of the author and not necessarily those of the State of California.

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Helen N. Tashima, Research Analyst II, provided general assistance with computer programs which extract data from DMV's driver record file and ensured that the data analyzed validly reflected the contents of DMV's records. Debbie McKenzie, Associate Governmental Program Analyst, prepared the final document and ensured that its format was consistent and clear. Douglas Luong, Office Technician, carefully prepared some of the drafts.

The author would like to dedicate this report to the memory of his mother, Eunice T. Marowitz.

Report Author:
Leonard A. Marowitz, Research Analyst II

EXECUTIVE SUMMARY

Background

- This study has several purposes and goals, which are:

  1. To determine if Blood Alcohol Concentration (BAC) measured at arrest could, along with other driving history and demographic factors, contribute significantly to the prediction of driving under the influence (DUI) recidivism.

  2. To statistically identify measurable factors predicting DUI recidivism which could be used in determining appropriate judicial and administrative sanctions and countermeasures for DUI offenders.

  3. To statistically identify DUI convictees at high risk to recidivate, relative to DUI convictees as a whole and relative to the rate of DUI convictions among the general driving population.

- Several studies have attempted to develop DUI typologies and characteristics in order to distinguish groups of offenders and their likelihood of recidivating, including:

  1. Epperson, Harano, and Peck (1975) concluded that problem drinkers tend to have worse driving records and higher rates of recidivism than social drinkers. The authors found a relationship between BAC at arrest and the number of prior had-been-drinking (HBD) arrests and total crashes.

  2. Tashima and Marelich (1989) found BAC levels for first and second offenders, but not third offenders, to be significantly related to alcohol-involved accidents and major convictions.

  3. Peck, Arstein-Kerslake, and Helander (1994) obtained DUI offender typologies indicating that the two most important dimensions underlying alcohol-related accidents and recidivism are the extent of aggressive unlawful driving and the severity of the offender's drinking problem.

- DUI convictees have often been viewed as a basically homogenous group. The identification of subgroups based on the probability of recidivism would change that view. The predicted probability of recidivism for a DUI convictee also provides an index of safety risk, since recidivists are known to have elevated accident risk levels (Peck, Arstein-Kerslake, & Helander, 1994).

Research Methods

- Subjects were persons arrested for DUI between January and June 1993, with administrative per se license suspension actions during this time period and subsequent convictions for DUI or reckless driving. A total of 53,217 offenders were used in the study.

- The study design had the following features:

  1. The first arrest date in the selection period served as a reference date which acted as a time period marker indicating the break between pre-arrest and post-arrest time periods.

  2. The dependent variable was a DUI event (DUI conviction or HBD accident) during the year after the DUI arrest. This variable had two values: present if at least one DUI event occurred and absent if none occurred.

  3. The initial independent variables included linear and nonlinear measures of BAC, prior 2-year counts of total convictions, alcohol/drug or reckless driving convictions, accidents, fatal and injury accidents, total convictions for driving with a suspended license, negligent operator points, HBD accidents, and DUI convictions. Other independent variables included 7-year prior DUI convictions, age, gender, whether the reference event was an accident or not, and offender level (first or repeat offense).

  4. Complex models were developed employing all independent variables. Simple main effects models were also developed in which only a few of the most significant factors from the complex models were used. The simple models were explored in order to develop a practical model for applied settings.

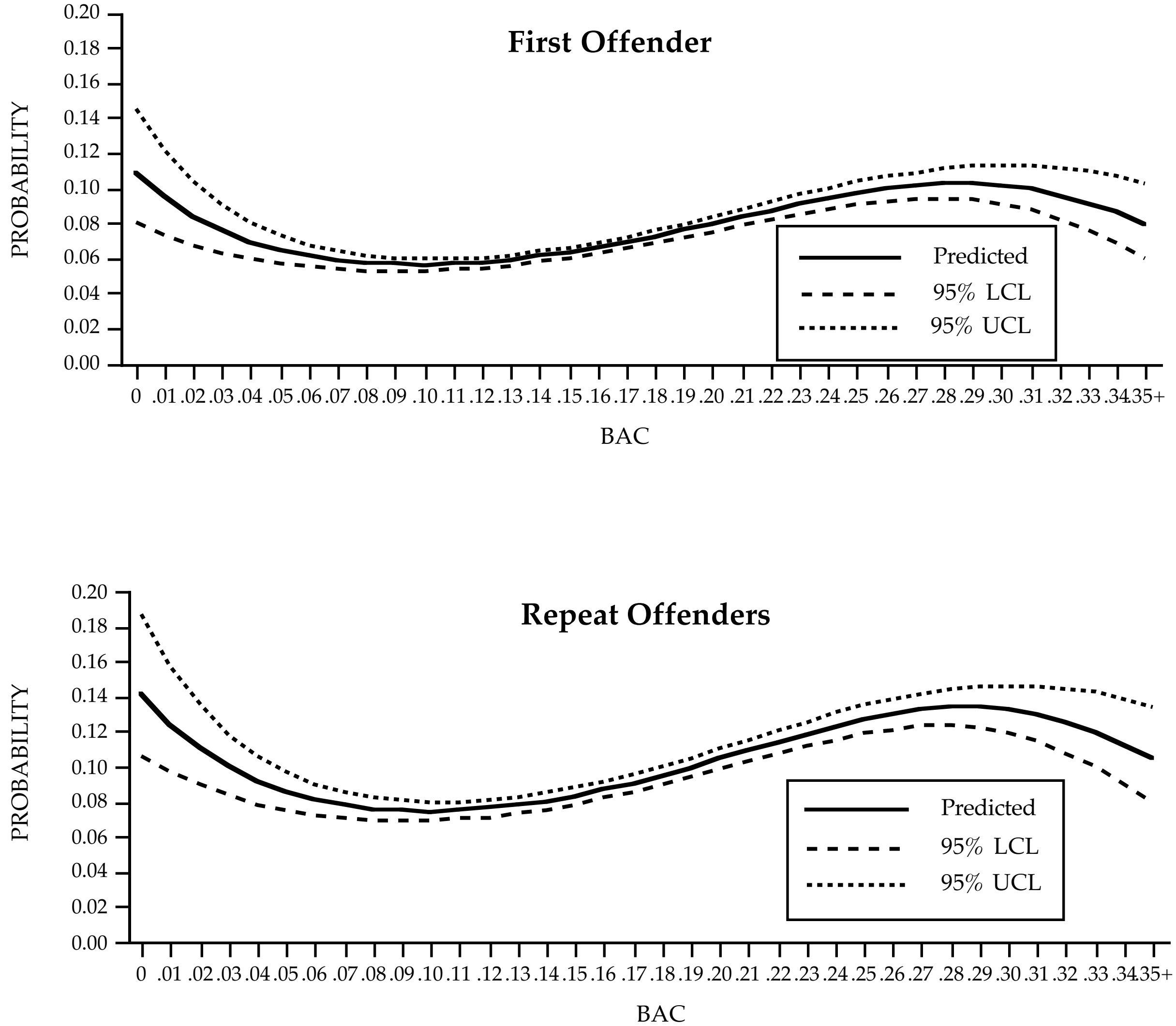
- Statistical analyses predicted whether or not subjects would recidivate during the year following their arrest.
- Along with all other factors, a series of analyses was conducted which enabled the relationships between first and repeat offenders, between BAC test-takers and refusers, and between combinations of these factors, to be determined relative to DUI recidivism.
- Additional statistical analyses correlated BAC levels at arrest with BAC levels at recidivism and constructed receiver operator characteristic curves to determine the most effective threshold for declaring individuals to be at high risk to recidivate.
- Tables and graphs were constructed for the simple model results which showed the absolute and relative probabilities of recidivating for combinations of significant variables.

Results

- All models involving BAC-tested convictees showed a significant nonlinear relationship between predictor variables and 1-year DUI recidivism. The lowest rate of recidivism was predicted to be at an arrest BAC level of about 0.09%, increasing as BAC either decreased to 0.00% or increased to about 0.29%. At the highest BAC levels, the rate of recidivism decreased.
- Significant predictors of 1-year DUI recidivism in the complex main effects only models were as follows:

  1. For BAC-tested convictees, DUI recidivism increased with prior 2-year total convictions, male gender, prior 2-year DUI convictions, repeat offense, and prior 2-year HBD accidents. DUI recidivism decreased with the reference event being an accident and with age. DUI recidivism varied with BAC in a nonlinear manner.
  2. For BAC refusal convictees, DUI recidivism increased with prior 2-year DUI convictions and repeat offense, and decreased with the reference event being an accident.
  3. A comparison of BAC-tested and refusal convictees, in which BAC could not be used as a factor, found all other significant factors to be the same as for the BAC-tested convictees only. In general, BAC refusals recidivated at a higher rate than BAC test-takers (combining both first and repeat offenders). BAC test refusers recidivated at the same rate as BAC-tested repeat offenders, but were 29% more likely to recidivate than BAC-tested first offenders.

- The simple model using BAC at arrest and offender level showed a significant nonlinear fit to the data. DUI recidivism was 35.4% more likely for repeat offenders than for first offenders. Figure 1 below shows that first and repeat offenders with zero and very low BACs at arrest were predicted to have rates of DUI recidivism comparable to the highest rates predicted for offenders with high BAC levels. The figure also shows that first offenders at some BAC levels have a greater probability of recidivism than repeat offenders.



Note: LCL = lower confidence limit and UCL = upper confidence limit.

Figure 1. Predicted probabilities of DUI recidivism based on BAC, BAC^2, and BAC^3.

- The simple model using BAC at arrest, prior 2-year total convictions, and offender level also exhibited a significant nonlinear relationship to the data. DUI recidivism was 25.3% more likely for repeat offenders than for first offenders, and each prior 2-year conviction increased the odds of 1-year DUI recidivism by 20.6%. Table 1 below is an abbreviated version of Table 17, found in the body of the report, which shows the percentile of recidivism for some combinations of BAC at arrest and prior 2-year convictions for first offenders.

Table 1

Combinations of BAC Level and Number of 2-Year Total Convictions Leading to Relative Recidivism Rates Equal to or Higher Than Each Tenth Percentile Predicted by BAC, BAC^2, BAC^3, and Prior 2-Year Total Convictions For First Offenders

BAC	Prior 2-year total convictions*					
	0	1	2	3	4	5+
0.00	80	90	90	90	90	90
0.05	10	40	50	80	80	90
0.10	0[a]	20	50	60	80	90
0.15	10	40	60	80	90	90
0.16	20	50	70	80	90	90
0.17	30	50	70	90	90	90
0.18	40	60	80	90	90	90
0.19	50	70	80	90	90	90
0.20	50	70	90	90	90	90
0.25	80	90	90	90	90	90
0.30	80	90	90	90	90[b]	90
0.35+	60	80	90	90	90[b]	90[b]

*Conviction count does not include reference conviction.
[a] Below the 10th percentile.
[b] Extrapolated values.

- BAC levels at recidivism were found to have a correlation of 0.533 with BAC levels at arrest. An additional analysis, dividing the BAC range of 0.00% to 0.35%+ into 5 equal steps, showed the highest correlations for the lowest and highest BAC levels at arrest. This suggests that a greater consistency of BAC level is present in these extreme groups.

- Figure 2 shows the nonlinear relationships between BAC and predicted rate of 1-year DUI recidivism for first and repeat offenders with one prior 2-year total conviction (similar patterns occur for other numbers of convictions). The figure reveals that the rates of recidivism for first offenders at some BAC levels are comparable to the rates of recidivism of repeat offenders at other BAC levels.

- The percentage of DUI convictees who would be considered to be at high risk to recidivate for any chosen cut-off probability of recidivism was determined. At a recidivism probability of 0.080, for example, about 40% of all BAC-tested DUI convictees would be classified as being at high risk to recidivate.

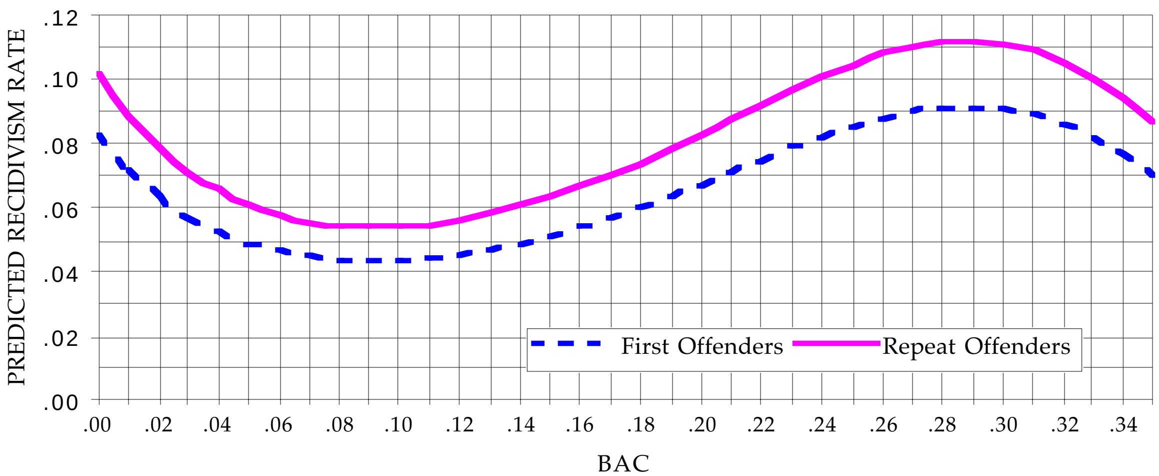


Figure 2. Predicted recidivism rate for first and repeat offenders with one prior 2-year total conviction.

Conclusions

- The BAC level at arrest of DUI convictees is statistically related to the probability of recidivism during the year following arrest. A nonlinear curve was fit with recidivism high at a BAC of 0.00%, decreasing to a BAC of about 0.09%, increasing to a BAC of about 0.29%, and then decreasing again to a BAC of 0.35% or greater.

- High rates of recidivism at high BACs suggest alcohol dependency, while at low BACs other impairing substances are suggested. Since users of intoxicating substances commonly use more than one such substance at a time, many DUI convictions reflect the use of both alcohol and other drugs.

- Prior 2-year total traffic convictions (moving and nonmoving violations) can increase predicted recidivism as much as a large increase in BAC level.

- The probability of DUI recidivism predicted by a simple model using BAC, prior 2-year total convictions, and offender level could be used by presentence investigators, judges, or in administrative settings to determine appropriate sanctions, treatment program assignment, or other remedial measures.

- The findings provide support for applying the same sanctions and treatment requirements to first offenders with high DUI recidivism probabilities as for repeat offenders with moderate probabilities. It may not be necessary to wait until drivers have been convicted of more than one DUI before considering them to be at high risk to recidivate. More intensive treatment for selected first offenders can potentially prevent or delay the commission of a second DUI offense.

- The findings provide support for viewing DUI convictees with very low BACs as probable drug users with relatively high recidivism likelihood, not as cases to be treated casually.

- Researchers divide persistent drinking drivers into at least two categories. The first consists of problem drivers who drink. These are individuals who drive aggressively and accumulate numerous moving violations. This group also tends to be overinvolved in other antisocial activities, including criminal offenses. The second category consists of problem drinkers who drive. These are individuals with an alcohol abuse problem. Individuals with high BACs (low BACs for drug abusers) are probably members of this group. The use of prior 2-year total convictions and BAC to predict DUI recidivism measures aspects of both groups.

- Further research should reanalyze these subjects using a 3-year pre-arrest period and a 3- to 5-year follow-up period. The greater period of time in which DUI recidivism can occur and the longer pre-arrest period in which to measure predictive factors should result in models with substantially increased predictive power.

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INTRODUCTION

Purpose of this Study

The purpose of this study is to determine if Blood Alcohol Concentration (BAC) measured at arrest could, along with other driving history and demographic factors, contribute significantly to the prediction of driving under the influence (DUI) recidivism. Does BAC provide information about the presence and degree of problem drinking, and about the probability of recidivism? Are drivers with a BAC of 0.08% the same as drivers with a BAC of 0.25%?

California law allows judges to enhance penalties if a DUI offender's BAC is above 0.20%. A study of sentences imposed under this law (Tashima, 1986) showed that first offenders with high BAC levels tended to receive jail sentences, while those with low BAC levels tended to receive driving restrictions. Sanctions given to second offenders did not vary with BAC level, but among second offenders convicted of DUI while driving with a suspended license, those with high BAC levels were more likely to be given additional sanctions than were those with low BAC levels. These findings show some acceptance of the premise that high BAC levels indicate a more severe drinking problem and a greater safety risk than do low BAC levels.

Perrine, Peck, and Fell (1988) reviewed studies on the epidemiology of drunk driving. They concluded that it is important to isolate characteristics associated with an increased likelihood of reoffending in order to improve early detection and treatment, as well as ensuring more focused sanctions for DUI convictees.

The ability to reliably predict DUI recidivism based on readily measurable factors would be an invaluable aid in determining appropriate judicial and administrative sanctions and countermeasures for DUI offenders. Several studies have attempted to analyze DUI convictees using varying types of factors in order to identify characteristics which distinguish groups of offenders and their likelihood of recidivating. Finally, even though the emphasis of this study is on recidivism, it is reasonable to conclude that countermeasures which reduce recidivism will also reduce alcohol-involved accidents.

DUI Typologies and Characteristics

Pollack, Didenko, McEachern, and Berger (1972) developed estimates of the probabilities of an initial and a subsequent drunk driving violation (recidivism) for drivers using a Bayesian classification model based on education, total number of minor traffic violations, age, number of accidents, and total number of non-traffic arrests, the majority of which were for public intoxication. An index number was assigned to each category of each factor, so that drivers could be fully categorized on the five factors by a five number index. Tables developed by McEachern (1972) from this prediction model contained probability estimates of initial and subsequent drunk driving violations ranging from less than 0.1 to greater than 0.9. Recidivism was associated with lower education and younger age, as well as with increased numbers of minor traffic violations, traffic accidents and total number of arrests. However, prediction accuracy was high only where there were very high probabilities of recidivism.

Nichols and Reis (1974) studied recidivism rates for types of drinkers. Problem drinkers had: (1) been diagnosed as an alcoholic, (2) admitted to alcoholism or problem drinking, or (3) had two or more of: (a) BACs of 0.15% or more, (b) one or more alcohol-related priors, (c) previous alcohol-related agency contacts, (d) life problems related to alcohol, or (e) diagnosis of problem drinker by an approved written diagnostic interview instrument. Non-problem drinkers did not satisfy these criteria. Problem drinkers had higher re-arrest rates than did non-problem drinkers at the end of the 18-month tracking period. The mean time to recidivate was the same for both groups.

Epperson, Harano, and Peck (1975) evaluated the possibility of classifying individual drivers into subtypes of drinkers corresponding to the type and degree of the individual's drinking problem and potential for DUI recidivism. They concluded that driving history has a slight but statistically significant relationship with drinking driver classifications such that problem drinkers tend to have worse driving records and higher rates of recidivism than social drinkers. The authors found that scores on the Risk of Addictive Problems Test (RAP) and the Mortimer-Filkins test (MF) have some validity as indices of problem drinking. In addition, they found that BAC was related to the number of prior HBD arrests, with the lowest number of prior HBD arrests seen for BAC levels of about 0.06% to 0.08%. As BAC varied from these levels, the number of prior HBD arrests increased. The authors found a similar relationship between prior total crashes and BAC level, with the lowest prior total crash rate occurring at 0.09% BAC. There was an increase in the number of prior total crashes associated with BAC levels that were higher and lower than 0.09%.

Wells-Parker, Landrum, and Cosby (1985) found that DUI arrestees could be placed into five groups based on their history of DUI offenses. The authors classified DUI offenders as problem drinkers if they had, among other things, a BAC of 0.20% or above on any offense, two or more previous drunken driving arrests, or BAC of 0.15% or above on any offense (includes public drunkenness) and a previous DUI arrest.

Marsh (1989) examined the potential contribution of BAC level to the identification of high-risk subgroups by dichotomizing DUI offenders based on BAC level at arrest. For offenders with BACs greater than 0.15% compared to those with BACs of 0.15% or less, there was a statistically significant, positive correlation with subsequent alcohol/drug incidents. The same was true when the BAC level for comparison was 0.20% and when it was 0.25%, with the 0.20% cutoff having the highest correlations with subsequent offenses for both first and second offenders. However, the magnitude of all of the correlations was very low.

Tashima and Marelich (1989) included BAC level in their analysis of the relative effectiveness of alternative sanctions for DUI offenders in order to determine if it would increase the fit of the regression equation above that accounted for by driver characteristics and sanctions. They found BAC level for first and second offenders to be significantly related to alcohol-related accidents and major convictions for both one- and two-year periods after arrest, with higher BAC levels being associated with increased rates of both alcohol-related measures. However, for third or greater offenders, BAC level did not add significantly to explaining the variance of either accidents or major convictions after subject variables and sanctions had been considered. The authors found that BAC was not a significant predictor of total accidents, which they felt reflected the presence of nonalcohol accidents in the total.

Wilson (1991) identified four typological clusters based on personality characteristics among drivers who had driving while impaired (DWI) convictions, accidents, or poor driving records. These clusters, which differed on the factors of thrill-seeking, hostility and personal adjustment, were called well-adjusted, deviant, irresponsible, and responsible/hostile. DWI and high risk or problem drivers (identified after accumulating traffic violation points, accidents or a combination of these) were distributed almost equally within each cluster. The author concluded that, based on the personality clusters obtained in this study, DWIs are not a subgroup of a larger population of high risk drivers. The two groups were found to be highly overlapping and largely indistinguishable. The author stated that greater success might be achieved if diagnostic instruments were developed which could identify subgroups of problem drivers, including DWI offenders, and if programs were developed to match the needs of the different subgroups.

Lewis, Kaplan, and Dorn (1993) evaluated first-time DWI offenders in order to identify factors which predicted violation of probation. Half of the probation revocations were due to a second DWI, while the rest were due to a variety of travel, residency, employment, and other reasons. The authors found that both preprobation criminal activity and preprobation drug use were associated with subsequent violations. They saw these factors as being indicative of persistent fundamental behavioral deviance.

Beirness, Simpson, Mayhew, and Wilson (1994) examined trends in drinking driver fatalities in Canada from 1973 to 1991. They found that the proportion of fatally injured drivers with BACs up to 0.15% had declined moderately, while the proportion with BACs over 0.15% had increased. The authors concluded that the greatest improvement in the drinking and driving problem over this period had been among light to moderate drinkers and that heavy drinkers had not been affected. They described this last group as probably either binge drinkers or chronic heavy drinkers and stated that hard core, heavy drinkers remain a problem that will require new strategies and techniques to decrease their DUI involvement.

Peck, Arstein-Kerslake, and Helander (1994) studied the psychometric and biographical correlates of drunk driving recidivism and treatment program compliance. Program compliance measures assessed treatment participation and included the number of educational sessions attended, number of counseling sessions attended, treatment termination date and reassignment, and nonassigned treatment participation. While DUI recidivism was predictable, it was found not to be of sufficient accuracy to guide treatment and sanction decisions in individual cases, except for extreme cases. Program compliance was found to be more predictable than DUI recidivism. Compliance and recidivism appeared to be related, as first and repeat offenders with noncompliant profiles were much more likely to have accidents and traffic convictions during the 4-year follow-up period. The DUI-offender typologies obtained indicated that the two most important dimensions underlying alcohol-related accidents and recidivism are the extent of aggressive unlawful driving (moving and non-moving violations) and the severity of the offender's drinking problem. The authors concluded by emphasizing the importance of distinguishing, as originally suggested by Simpson (1977), between "the problem driver who drinks" and "the problem drinker who drives" as different offender types.

Biecheler and Fontaine (1994) found that accident involvement is determined by interactions between gender, age, profession, annual mileage, proportion of weekend and night-time driving, and drinking habits. High risk offenders were characterized by high correlations among demographic and socio-cultural characteristics (young men, daily consumption of alcohol, varied mobility, frequent night-time, and weekend driving) and repeated driving behavior (multiple offenses, intolerance towards other drivers in situations where their speed or driving space are affected). The authors concluded that alcohol is very important among these risk factors and whatever the quantities consumed and the circumstances, drivers think they can drive normally after drinking and do not acknowledge the increased risk to their own safety.

Brewer, Morris, Cole, Watkins, Patetta, and Popkin (1994) examined the risk of dying in alcohol-related crashes among habitual drunk drivers by comparing the prior driving records of driver fatalities with BACs of at least 0.20% (called case drivers) to those with BACs below 0.20% (called control drivers). A larger percentage of case drivers (26.2%) than control drivers (3.1%) had histories of DWI arrests. After adjusting for age and gender, the authors found a strong positive association between a history of DWI arrests and subsequent alcohol-related driver deaths. This association varied significantly with the driver's age at death. Fatally injured drivers aged 21 to 34 years were four times as likely as controls to have had one or more arrests for DWI, while others aged 35 years or older were 12 times as likely to have had one or more arrests for DWI. The authors stated that this age-related difference "may be related to the natural history of alcoholism." They suggested that a DWI arrest may present an important opportunity to decrease the risk of future death from an alcohol-related crash through effective intervention.

Hedlund (1995) reviewed definitions and characteristics associated with the persistent drinking driver. Studies cited by the author found that such drivers tend to be younger, male, single, beer drinkers, with mean BACs of 0.18% - 0.28%. They also tend to be problem drinkers with prior DWIs and/or marital or family difficulties who are frequently aggressive, hostile, sensation-seekers with histories of other criminal behavior. They drive after drinking an average of 13 times per month. The author concluded that persistent drinking drivers are those who have repeatedly driven after drinking, especially with high BACs.

Friedman, Harrington, and Higgins (1995) evaluated the factors which influenced how motorists became repeat offenders by studying 508 offenders with five or more alcohol-related convictions. Over half of the offenders had an ongoing series of drinking and driving events for over 10 years. The authors proposed the existence of two types of recidivists: those inclined to obey the law but who had a severe problem of alcohol abuse and those not inclined to obey the law with alcohol abuse being one of many antisocial behaviors. They hypothesized that the former group would be more likely to complete a treatment program, while the latter group would have little motivation to do so. In other words, an inclination to obey the law among those with a severe problem of alcohol abuse is consistent with an inclination to complete a treatment program, while antisocial individuals who are not inclined to conform to the legal system would be similarly not inclined to complete treatment programs.

Alcohol and Other Drugs

Terhune, Ippolito, Hendricks, Michalovic, Bogema, Santinga, Blomberg, and Preusser (1992) studied drug incidence and accident responsibility among driver fatalities from seven states in 1990 and 1991. They found drugs other than alcohol in 17.7% of driver fatalities, but collected and analyzed blood samples from only 69.7% of the driver fatalities who met the criteria for inclusion in the study. The authors cited a possible bias due to underrepresentation of weekend fatalities in their sample relative to eligible Fatal Accident Reporting System (FARS) weekend fatalities. They made a bias adjustment by adding a weighting variable to adjust for the ratio of FARS cases to sample cases. However, in California[1] and possibly elsewhere, drug testing of driver fatalities is not performed in all instances. Thus, the FARS drug eligible data underestimate the actual presence of drugs in driver fatalities, and the weighting used in this study leads to an underestimate of the actual presence of drugs in the adjusted sample.

Stoduto, Vingilis, Kapur, Sheu, McLellan, and Liban (1993) screened seriously injured motor vehicle collision victims in Toronto, Canada, between August 1986 and August 1989 for alcohol and drug use. They found that among drivers, 35.5% tested positive for alcohol, 41.3% tested positive for drugs other than alcohol and 16.5% tested positive for both alcohol and other drugs. A trend toward a significantly higher BAC was found for drivers who tested negative for drugs.

Marowitz (1994) compared the driving records of California drug arrestees, during the year prior to their arrest and the two years after their arrest, to those of the general driving population. Drug arrestees had significantly more traffic violations (2.38 times as many) and significantly more accidents (1.45 times as many) during the entire three-year period, despite many of them being incarcerated during part or all of the two years after arrest. Direct and indirect measures of accident culpability evaluated for the year prior to arrest showed drug arrestees to have significantly more single-vehicle accidents and greater responsibility for the accidents in which they were involved. Drug arrestees also had relatively higher rates of fatal and injury accidents and lower rates of property-damage-only accidents.

Brookoff, Cook, Williams, and Mann (1994) evaluated the drugs present in 150 of 175 subjects stopped for reckless driving at night, who were not under any apparent influence of alcohol. Fifty-nine percent tested positive for at least one drug, with marijuana and cocaine being the most commonly found drugs. More than half of the drivers who were found not to be intoxicated by alcohol were found to be intoxicated by other drugs.

Phillips (1995) screened all drivers in 46 California counties from 1992 to 1994 who were arrested for impaired driving, but who had BACs of 0.08% or less, for the presence of

[1] Determined after examining California FARS data for 1993 and consulting with a sample of county coroner offices. Drug testing of driver fatalities occurs to varying extents and for varying reasons among the counties surveyed. Not all counties test for all drugs. The high cost of drug tests appears to be a major reason why they are not universally performed.

opiates, methamphetamine, benzodiazepines, cocaine, phencyclidine and marijuana. Approximately 60% tested positive for drugs. Drugs were present at all BAC levels screened but were most present at a BAC of zero. As BACs increased, the number of samples negative for all six drug categories rose. Methamphetamine and marijuana were a common combination. The author stated that drug use patterns of individuals driving under the influence of drugs were similar to the patterns of use seen among those abusing controlled substances in general.

Alcohol as an Addictive Drug

It is generally accepted in the medical literature that alcohol is a highly addictive drug. Estimates that 10 percent of adults have drinking problems, and that 3 to 5 percent are extremely dependent on alcohol, are commonly made. The California Department of Alcohol and Drug Programs estimates that two million California adults have alcohol abuse problems, and that 600,000 to one million California adults are extremely dependent on alcohol (C. Chaffee, personal communication, June 23, 1995).

As described above, studies have dichotomized DUI convictees into groups of problem drinkers versus non-problem drinkers. It would not be unreasonable to hypothesize that the great majority of DUI convictees in California are problem drinkers and that a substantial percentage of them meet standard diagnostic criteria for alcoholism. Many of these individuals use their automobiles routinely in the daily commerce and leisure of their lives. Many of these individuals are also not discretionary consumers of alcohol who can choose not to drink as readily as they can choose to drink. For these individuals, alcohol is an addiction, with the need for alcohol being a central focus and motivation of their behavior and thinking (Brown, 1985).

DUI convictees have often been viewed as a basically homogenous group, differing along a quantitative continuum that is measured by factors such as BAC and the number of prior DUI convictions. As these factors increase numerically, DUI convictees receive increasingly harsh court and administrative sanctions. This study will address the potential of DUI convictees being divided into distinct subgroups which have different probabilities of recidivism. These subgroups might be formed from cutoffs derived from a regression equation used in this study, as opposed to factor, cluster or conceptual typology grouping. The predicted probability of recidivism for a DUI convictee also provides an index of safety risk, since recidivists are known to have elevated accident risks (Peck et al., 1994). The development of a statistically based classification scheme enables objective, measurable criteria to be used in placing DUI convictees into subgroups.

Goal of this Study

The goal of this study is to evaluate variables available from the driving record which can be used to identify DUI convictees who have a high risk to recidivate, relative to DUI convictees as a whole and to the rate of DUI convictions among the general driving population.

Drivers who are stopped for a possible DUI violation are asked to take a chemical test to determine their BAC. Most drivers agree to take a BAC test[2], while some refuse to be tested. This study will analyze drivers who agreed to testing and whose driver records

[2] Drivers have the choice of having their breath, blood, or urine tested in order to determine BAC.

contain BAC levels. It will also examine drivers who refused to be BAC tested. These drivers, who will be referred to as "refusals," are evaluated among themselves and in comparison to drivers who took BAC tests.

Three types of predictive models will be developed. The first will include only BAC levels at arrest. The second will include all available driver record factors which are potentially significant predictors. The third will include a smaller number of significant factors from the second model for use in a practical, applied setting. The first and third types of models will be developed only for BAC tested drivers, while the second type will be developed for both BAC tested and BAC refusal drivers.

METHODS

Subjects

Subjects were persons arrested for DUI between January 1, 1993 and June 30, 1993 who were subsequently convicted of DUI or reckless driving. Arrestees were identified from a computer file consisting of drivers who had administrative per se license suspension actions imposed during this time period. License action codes on driver records indicated if the subject's BAC was measured at the time of arrest or if the arrestee refused to be tested. These codes also indicated whether the driver was a first or repeat offender.

License action codes indicated that during the study period 67,825 DUI convictees agreed to, and 5,337 DUI convictees refused, BAC testing. Of those DUI convictees who agreed to testing, BAC values could be found on 47,880 (70.6%) of the driver records, while they could not be found on the remaining 19,945 (29.4%) of the records. Records of these two groups of BAC-tested convictees were compared to determine if those containing BAC values could be considered to be representative of the records of all arrestees who agreed to BAC testing.

A total of 53,217 subjects were used in this study. These subjects were broken down into first and repeat offenders as follows:

	BAC test	BAC refusal	Total offender types
First offenders	32,029	2,658	34,687
Repeat offenders	15,851	2,679	18,530
Total sample	47,880	5,337	53,217

Design

The subjects in this study represented the entire population of eligible drivers. Entry into the study was a result of driving while impaired, which led to apprehension by law enforcement and conviction by a court. While DUI arrests and convictions have been decreasing steadily over recent years, there is no evidence to suggest that there have been basic changes in the reasons why people drive while impaired or that past driving behavior does not remain a significant predictor of future driving behavior.

A file of all drivers receiving administrative per se license actions for DUI between January 1, 1993 and June 30, 1993 was used to extract driver records from the driver record file of the California Department of Motor Vehicles. The arrest date served as a reference date which acted as a time period marker. All prior time periods included and ended on the arrest date, while the post-arrest time period began after the arrest date. If a driver had more than one DUI arrest during the time that subjects were being identified, the first arrest served as the reference event and any further arrests or accidents which occurred were considered as subsequent events.

The dependent variable used in this study was a DUI event (HBD accident or DUI conviction) during the year after the DUI arrest. This variable had two values: present, if at least one DUI event occurred during the time period, and absent, if no DUI events had occurred.

The 14 initial independent variables included BAC at arrest, prior 2-year counts of total convictions, alcohol/drug or reckless driving convictions, accidents, fatal and injury accidents, total convictions for driving with a suspended license [California Vehicle Code (CVC) §14601], negligent operator points, HBD accidents, and DUI convictions. Other independent variables included prior 7-year DUI convictions, age, gender, whether the reference event was an accident or not, and if the violation was for a first or repeat offense.

Three general models were developed. The first was a polynomial regression model which used only BAC level, to the degree necessary, to acceptably model the empirical response surface. The second was a complex model which began with all 14 potential independent variables, using solely main effects, and eliminated them iteratively until only significant contributors remained. The significant main effects and 2-way interactions that could be made from them were used as potential independent variables to generate another predictive equation using the same iterative technique. The third model drew on the second by choosing a few of the most significant factors and developing a simple, practical, main effects model that could be applied in real-world situations. Two equations, one based on two factors and the other based on three factors, were developed.

Statistical Analyses

Discriminant analyses were used to determine if driver records showing BAC values were different from those of BAC-tested drivers without BACs on their records, and, if so, what variables explained the difference. Discriminant analyses were performed using the SAS statistical software CANDISC and STEPDISC procedures (SAS Institute Inc., Version 6, 1990a).

Orthogonal regression was used to determine which order polynomial best predicted the rate of occurrence of a 1-year post-arrest DUI event as a function of BAC level and age. Orthogonal polynomials constitute a new set of variables based on linear combinations of natural polynomials and avoid the collinearity inherent in the use of natural polynomials. Orthogonal regressions were performed using the SAS statistical software ORTHOREG procedure.

Hierarchical cluster analysis of independent variables was performed using centroid components in order that the cluster components would be unweighted averages of the standardized variables. Clustering was performed to aid in determining which of these variables were statistically redundant and unnecessary. Significant variables in the final regression equations were compared to clustering which had the same number of clusters as there were significant variables. A comparison was made of the variables present in each cluster and the significant regression variables to see if cluster formation and the prediction of DUI recidivism were the result of the same or similar variables. Patterns of grouping of variables (e.g., accident measures) and their splitting into separate clusters were also noted. Clustering was done using the SAS statistical software VARCLUS procedure. Tree diagrams, or dendrograms, using data created by the VARCLUS procedure were produced by the SAS statistical software TREE procedure to assist in visualizing the pattern of splitting variables into clusters.

Logistic regression was used to develop equations to predict whether or not subjects would recidivate during the year following their arrest. It should be noted that this binary measure did not differentiate the number of DUI events occurring in the subsequent year, only if a DUI event occurred or not. However, very few offenders would have accumulated more than one reoffending event.

Logistic regression analyses were carried out using the actual model syntax, in which the data are entered ungrouped, and also the events/trials model syntax, in which the data are grouped. The actual model syntax specifies one variable as the response variable and was used when many independent variables were put into an equation, as in the complex models. The events/trials model syntax specifies two variables: events, which is the number of positive events (subjects with at least one DUI event in this study), and trials, which is the number of trials (number of subjects at each BAC level or at each BAC level and number of 2-year prior total convictions combination, in this study). The quotient obtained by dividing events by trials is the group response variable and was used when few independent variables were put into the equation, as in the simple models.

The actual model syntax calculates predicted values for individuals along with 95% confidence limits for individuals, while the events/trials model syntax calculates predicted values for group means along with 95% confidence limits for group means.

Forward selection and a significance level to enter the equation of 1.0 were used to force all independent variables into equations without regard for hierarchical distinctions between main effects and 2-way interactions (unique model). Once in equations, independent variables which were not significant predictors in the presence of all other factors, as evidenced by nonsignificant Wald chi-square probabilities, were eliminated and the remaining factors were analyzed. Main effects were adjusted for significant interactions and nonsignificant main effects were kept in models in which they were components of significant 2-way interactions.

Elimination was by the $p > 0.05$ criterion. Remaining significant factors were used in the subsequent logistic regression analysis. This iterative procedure, which developed a parsimonious model, was continued until all remaining factors were significant at the

$p<0.05$ level. Odds ratios, which show how much more likely one outcome is over another for each unit increase in a factor, were obtained for all factors.

Both main effects, alone, and main effects plus 2-way interactions were analyzed in the complex models, while only main effects were analyzed in the simple models. Overall model fit was assessed using the -2 Log Likelihood (L) statistic, which has a chi-square distribution for the null hypothesis. The p-value for this statistic is also shown. The SAS software LOGISTIC procedure was used.

Logistic regression analyses were conducted in which the following comparisons were made, along with all other factors:

BAC first offenders	versus	BAC repeat offenders
Refusal first offenders	versus	Refusal repeat offenders
All BAC offenders	versus	All Refusal offenders
BAC first offenders	versus	All Refusal offenders
BAC repeat offenders	versus	All Refusal offenders

The calculated odds ratios for increased risk of a 1-year post-arrest DUI event between various pairs of these groups enabled the development of a hierarchy of risk among all these groups.

Probabilities of recidivism were estimated using the logistic regression equation with model parameters. The linear logistic model is of the form:

$$\text{logit}(p) = \log(p/1 - p) = \alpha + \beta' \text{x},$$

where p = response (recidivism) probability, α = intercept, and β' = vector of slope parameters. The value obtained for logit(p) is used to calculate p as follows:

$$p = e^{\text{logit}(p)} / (1 + e^{\text{logit}(p)})$$

BAC levels associated with convictions were correlated with BAC levels measured at recidivism. In a small number of cases, where no BAC level was available for the first recidivist event but was available for a subsequent arrest, the subsequent arrest BAC level was used instead. In other cases with a recidivist event without BAC level, if a prior BAC level was available, that level was used as the entry event and the arrest associated with subject selection was used as the recidivist event. In both of these cases, the subsequent or prior arrest occurred within 15 months of the reference arrest. The SAS software CORR procedure was used (SAS Institute Inc., Version 6, 1990b).

Receiver operator characteristic curves were constructed for all final logistic regression models using the classification tables obtained in the SAS software LOGISTIC procedure. The area under each curve, which is a measure of the predictive capability of a model, was obtained from the c statistic output by the LOGISTIC procedure. The most effective combinations of sensitivity (predicting an event that occurs) and specificity (predicting the absence of an event that does not occur) for determining the recidivism threshold for each model were estimated from each curve. For each model, the number and percentage of subjects who were predicted to recidivate at specified values of the model equation were determined.

Data from the classification tables were also used to construct 2 x 2 contingency tables of predicted outcomes and observed outcomes for each model. Optimum prediction values, defined as the model equation value which results in the same distribution of predicted outcomes as observed outcomes and which maximizes the phi coefficient (Pearson coefficient between two outcome categories), were calculated for each model. These values were determined by estimating the probability level where the total number of predicted (correct and incorrect) recidivists equals the total number of observed recidivists. At this probability level, the contingency table marginal distributions are the same and result in equivalent proportions of false negative and false positive error, which by implication gives equal weight to the sensitivity and specificity of the prediction model. The optimum probability level was obtained by extrapolating from the probability levels shown by the classification table to be associated with total number of predicted recidivists just greater than and just less than the 3,681 recidivists observed in the study to the probability level which predicted 3,681 recidivists.

The possible presence of a reversal of the pattern of recidivism relative to BAC level, in which a decrease was seen at intermediate values, was evaluated. That reversal phenomenon, known as Simpson's Paradox, results when non-homogeneous subgroups are present, none of which exhibits the paradoxical decrease and all of which show a monotonic increase in outcome relative to a predictive factor (Hurst, Harte, & Frith, 1994). For this study, a reversal would be present if all subgroups showed recidivism increasing monotonically with BAC level, despite the nonmonotonic relationship seen for the collapsed data. This evaluation was carried out using observed data and graphically comparing the relationship between recidivism and BAC level for the collapsed data and for subgroups based on age and gender.

RESULTS

BAC-Tested Convictees

Discriminant analyses were performed to determine if BAC-tested convictees (Department of Motor Vehicles Action Reason Codes 966, 967, & 979) on whose driver records BAC levels could be found differed based on 13 independent variables and one dependent variable used in this study from those on whose records BAC levels could not be found. If the records with BAC levels could not be found statistically to belong in a separate group from those without BAC levels, then the records with BAC levels present could be considered to be representative of all BAC-tested convictees.

The canonical discriminant analysis resulted in a significant likelihood ratio of 0.9941 (approximately F = 28.5057; p = 0.0001; df_n = 14; df_d = 67,810), indicating a statistically significant difference between BAC and non-BAC subjects on the variables used. However, the squared canonical correlation (analogous to R^2) for the overall equation was 0.59%. This very low association means that the overall equation explained very little of the variance of the groups and that any bias due to missing value would be negligible.

The stepwise discriminant analysis with forward selection showed seven individual variables to be significant discriminators ($p \leq 0.01$). However, all of these had very small partial R^2 values, indicating that none of them explained very much of the variance of the groups. DUI convictions in the previous two years was by far the strongest discriminator. Inspection of the discriminant coefficients indicated that offenders with missing BAC values tended to have more prior DUI convictions.

The results of this analysis of individual variables are summarized in Table 1.

No such comparison was required for BAC refusals (DMV Action Reason Codes 968, 975 & 978), as all these DUI convictees are included in this study. That is, all convictees who refused BAC testing were identified as such, and there were no known instances where a convictee refused BAC testing where this refusal was not indicated on the driving record.

Table 1

Summary of Discriminant Analysis of BAC-Containing and BAC-Missing Driver Records for BAC-Tested Drivers

Variable	F	p	Partial R^2
Prior 2-year DUI convictions	261.874	0.0001	0.38%
Age	34.647	0.0001	0.05%
First offenders	32.772	0.0001	0.05%
Prior 2-year alcohol/drug or reckless convictions	31.353	0.0001	0.05%
Prior 7-year DUI convictions	12.337	0.0004	0.02%
Prior 2-year negligent operator points	8.320	0.0039	0.01%
Prior 2-year fatal & injury accidents	6.617	0.0101	0.01%
Gender	3.176	0.0747	0.00%
Prior 2-year suspensions	2.630	0.1049	0.00%
Post 1-year DUI convictions	2.036	0.1536	0.00%
Prior 2-year HBD accidents	1.353	0.2448	0.00%
Reference event an accident	0.792	0.3734	0.00%
Prior 2-year accidents	0.579	0.4468	0.00%
Prior 2-year total convictions	0.017	0.8948	0.00%

BAC Level at Arrest as the Sole Predictor of Subsequent 1-Year DUI Recidivism

The overall mean BAC level for tested drivers was 0.162%. First offenders had a mean BAC level of 0.157%, while repeat offenders had a mean of 0.173%.

The mean observed rate of at least one DUI recidivism event (i.e., presence or absence of recidivism) for all convictees at each BAC level are shown in Table 2. In general, observed recidivism is high at the lowest BAC levels, decreases from 0.05% BAC to 0.09% BAC, increases again up to a BAC level of 0.31% and then decreases.

Table 2

Mean Observed Rate of at Least One DUI Recidivism Event for Each BAC Level

BAC	Subjects	Mean rate of DUI recidivism*
0.00	218	0.1376
0.01	42	0.1429
0.02	32	0.0625
0.03	27	0.1481
0.04	31	0.0645
0.05	50	0.1000
0.06	78	0.0897
0.07	209	0.0766
0.08	1393	0.0510
0.09	1987	0.0498
0.10	2747	0.0633
0.11	3108	0.0637
0.12	3375	0.0584
0.13	3348	0.0624
0.14	3544	0.0677
0.15	3449	0.0702
0.16	3366	0.0737
0.17	3177	0.0825
0.18	2878	0.0876
0.19	2629	0.0848
0.20	2437	0.0845
0.21	1961	0.0852
0.22	1607	0.1008
0.23	1373	0.0976
0.24	1105	0.0986
0.25	835	0.1162
0.26	695	0.1026
0.27	529	0.1229
0.28	400	0.1025
0.29	325	0.1046
0.30	232	0.1164
0.31	188	0.1596
0.32	121	0.0992
0.33	98	0.0816
0.34	86	0.1047
0.35 and above	203	0.1084

*Since the criterion is binary (recidivate or not), the mean is really a proportion.

Orthogonal regressions were performed with BAC as a first, second, or third degree polynomial. All BAC values of 0.35% or greater were pooled. The resulting equations and predicted values are presented in Figures 1, 2 and 3. In each case the observed values are also shown.

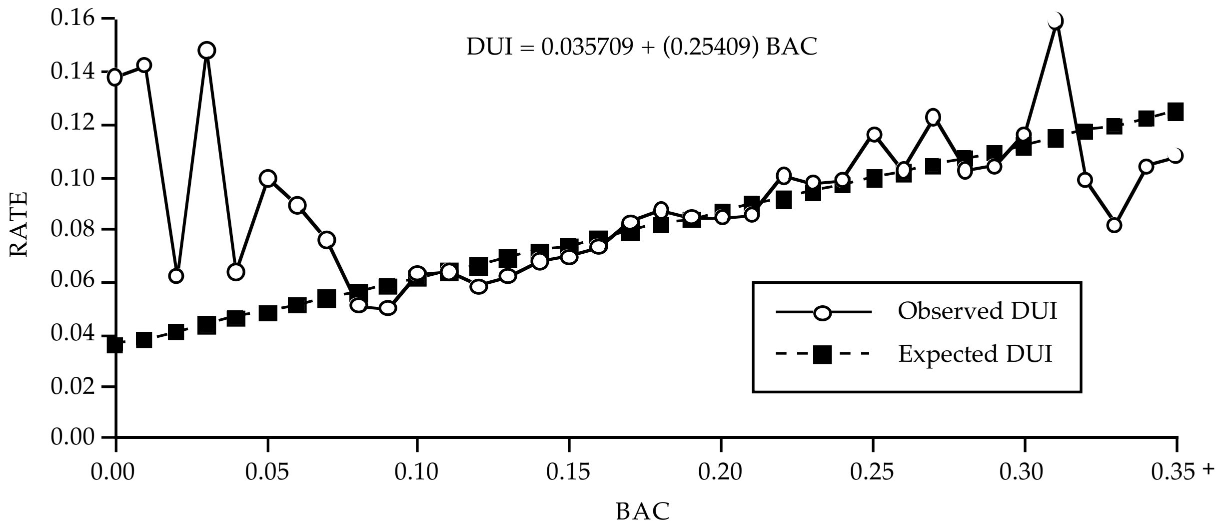


Figure 1. BAC (linear) versus rate of a 1-yr post DUI event.

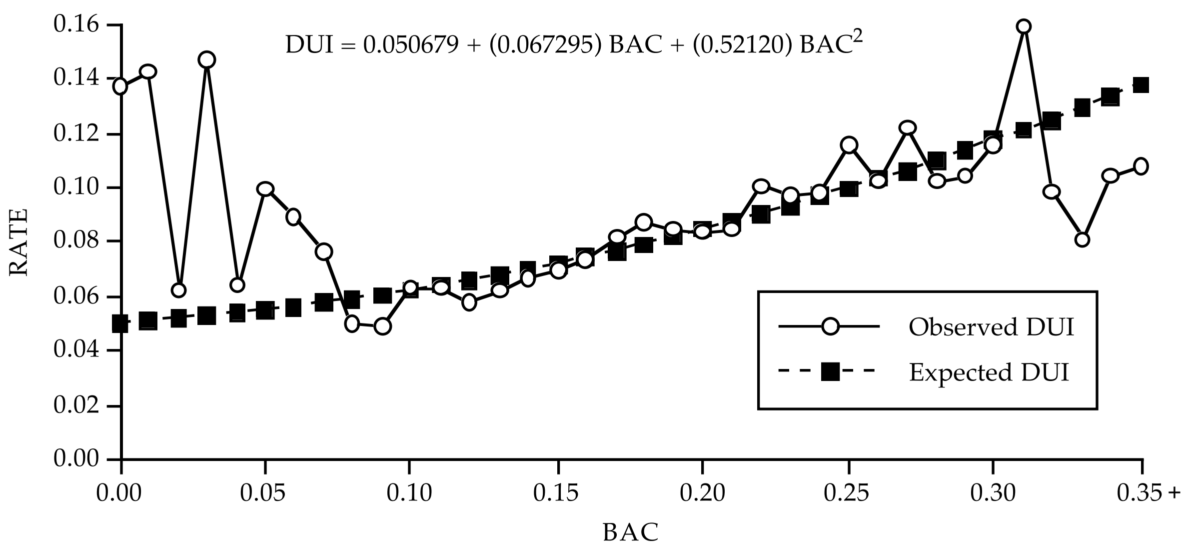


Figure 2. BAC (quadratic) versus rate of a 1-year post DUI event.

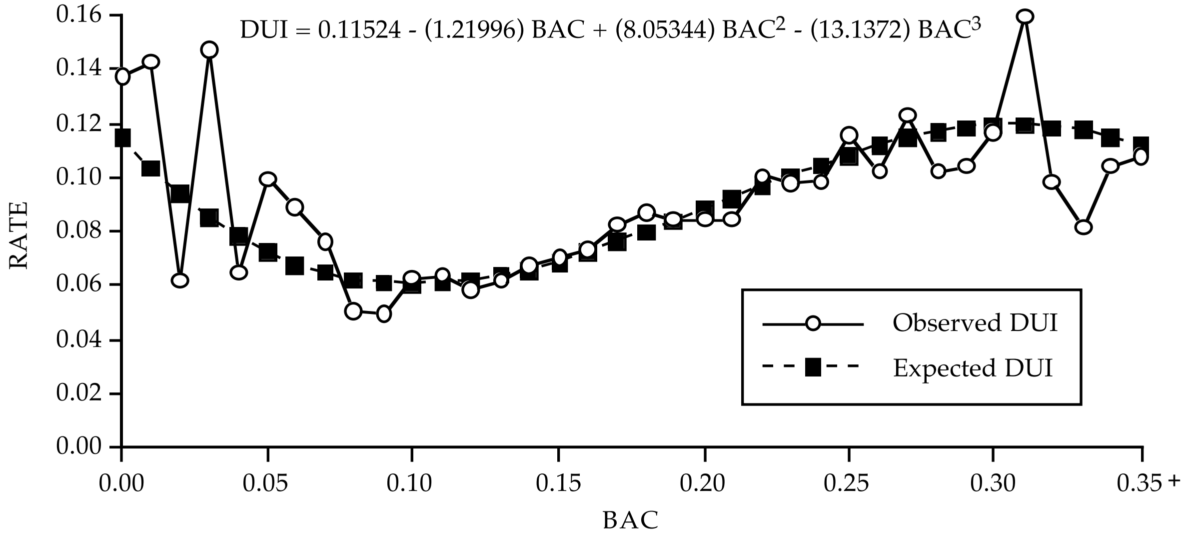


Figure 3. BAC (cubic) versus rate of a 1-year post DUI event.

These figures clearly show that the third degree or cubic polynomial most closely fits the observed data, and indicate that the predicted rate of DUI recidivism is lowest (among convicted DUI offerders) for those with BACs of 0.10%. The predicted probability of recidivism increases as BAC increases up to a maximum predicted probability of 0.120 at a BAC of 0.31%, and then the predicted rate decreases with increasingly higher BAC levels. Unexpectedly, the predicted rate of DUI recidivism also increases as BAC levels decrease below 0.10%, increasing to a predicted rate of 0.115 at a BAC of 0.00%. Thus, the predicted DUI recidivism rate for DUI convictees with no measurable BAC is almost as great as for the positive BAC level with the highest DUI recidivism rate. Reasons for this nonlinear relationship are presented in a subsequent section of this report.

It is important to remember that many DUI convictees received license suspension as a sanction. About 75% of those suspended for DUI have been found to drive while suspended, although they apparently drive more cautiously in order to avoid detection (Hagen, McConnell, & Williams, 1980). Thus, the rates of recidivism cited are rates that occurred despite many of the DUI convictees being suspended for all or part of the year following their arrest. If no suspensions had occurred, higher rates of recidivism would have been expected as a result of greater exposure. Similarly, many DUI offenders are assigned to alcohol treatment programs, which have been found to have some benefit in reducing recidivism. This effect would also reduce reoffense rates and possibly attenuate the relationship between BAC and the probability of reoffending.

Age as the Sole Predictor of Subsequent 1-Year DUI Recidivism

Orthogonal regression using age as the sole predictor of subsequent 1-year DUI recidivism showed a significant negative linear fit (p = 0.01) between age and recidivism, while quadratic and cubic fits were not significant. The obtained equation and predicted values are shown, along with observed values for each age, in Figure 4.

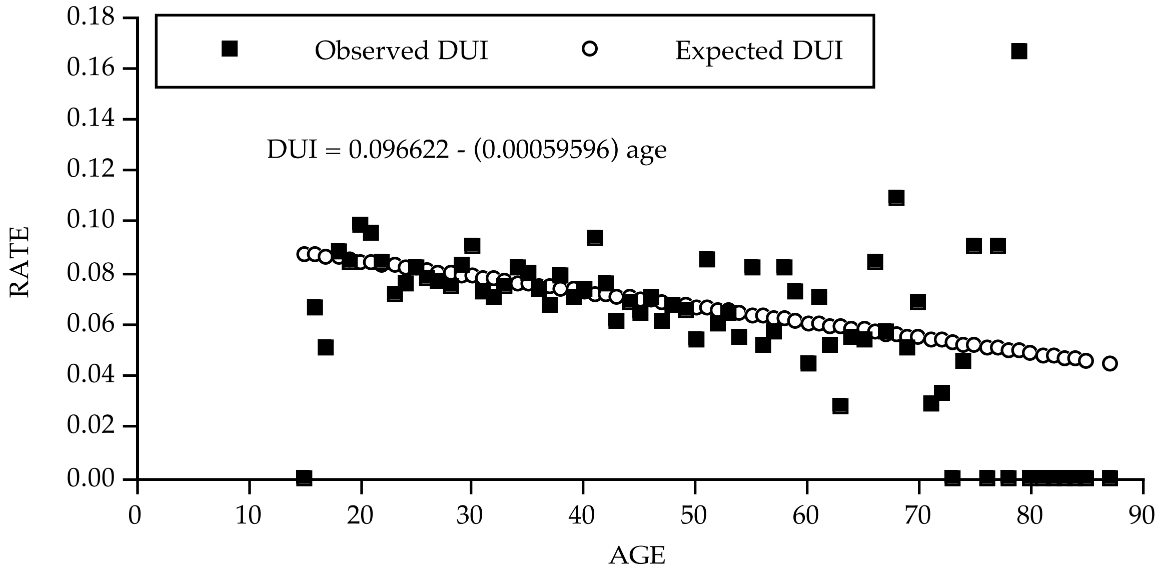


Figure 4. Age versus rate of 1-year post DUI event.

When only age is considered, there is a decreasing rate of DUI recidivism with increasing age. Drivers aged 16 and 17 were exceptions to this trend, with these drivers having lower rates of recidivism than drivers in their late teens and early twenties.

Logistic Regression Model Predicting Subsequent 1-Year DUI Recidivism: Complex Model, Main Effects Only

BAC-Tested Convictees. The following six variables were not statistically significant predictors of recidivism using the forward selection logistic regression procedure described earlier: prior 2-year accidents, fatal and injury accidents, alcohol/drug or reckless convictions, license suspensions, negligent operator points, and prior 7-year DUI convictions.

Cluster analysis with eight clusters showed that of the eight factors remaining in the logistic regression backward elimination procedure, seven were in different clusters when all 14 original factors were entered into the cluster analysis. Therefore, the variables which differentiated recidivists from nonrecidivists also defined the different subgroups identified by the cluster analysis. Cross correlations showed that only the two factors that were in the same cluster, reference accident and prior 2-year HBD accidents, were highly correlated. These two factors appeared to be measuring different aspects of accident involvement, with prior 2-year HBD accidents reflecting more historical phenomena and reference accident reflecting the effect of a current event on near-term behavior. It should be noted, incidentally, that part of the correlation between these two accident measures reflects a spurious part-whole component since the referent accident is included in the 2-year accident count.

DUI convictees who agreed to BAC testing were analyzed as described earlier in order to determine the relative risk of recidivating, and to find factors which were significant predictors of recidivism for these drivers. Among DUI convictees who agreed to BAC testing, the odds of recidivating increased by 13.5% for each prior 2-year total conviction, 17.6% for each prior 2-year DUI conviction, 56.9% for male versus female gender, 14.8% for repeat versus first offenders, and 24.2% for each prior 2-year HBD accident. The odds of recidivating decreased by 45.5% if the reference event involved an accident, and by 0.8% for each one year increase in age. The results are shown in Table 3.

Table 3

Logistic Regression Model for BAC-Tested Convictees, Main Effects

Variables	Chi-square at entry	Entry sequence	Wald chi-square at end	Pr > chi-square	Final regression coefficients	Odds ratios
Intercept	------	------	207.4600	0.0001	-3.1041	0.045
2-year Total convictions	227.6	1	129.7977	0.0001	0.1262	1.135
BAC^2	188.8	2	52.0023	0.0001	116.6	*
Gender	67.7066	3	55.3429	0.0001	0.4503	1.569
2-year DUI convictions	54.1799	4	15.6578	0.0001	0.1621	1.176
Reference event an accident	46.9593	5	40.2878	0.0001	-0.5891	0.555
BAC^3	22.1822	6	45.9860	0.0001	-193.6	*
BAC	33.9995	7	34.5586	0.0001	-16.9641	*
Age	19.7880	8	21.9413	0.0001	-0.00848	0.992
Offender level	11.9683	9	11.4021	0.0007	0.1384	1.148
2-year HBD accidents	8.2769	10	8.2612	0.0041	0.2169	1.242

-2 Log *L* for intercept = 25958.771; -2 Log *L* for intercept and covariates = 25320.759; chi-square for covariates = 638.012, $df = 10$, $p = 0.0001$

*The overall odds ratios for BAC, BAC^2, and BAC^3 reflect the high degree of collinearity inherent in polynomial components. The best way to determine the odds ratio for BAC is to use the three polynomial terms as a set to predict rates of recidivism for specific pairs of BAC levels, holding all other factors constant. For example, for a 30-year old man convicted of a first DUI with no prior accidents or convictions of any type on his driving record, the odds of recidivating with BACs of 0.20% and 0.30%, relative to a BAC of 0.10%, are 1.518 and 2.288, respectively.

Recidivism as a Function of BAC Status (Tested Versus Refused). Beginning with the factors in the final main effects model obtained for the BAC-tested convictees, but excluding BAC, BAC^2 and BAC^3 (because these factors were not available for BAC refusals), iterative logistic regression analyses were performed as described earlier to compare BAC test-takers to BAC refusals. This was done in order to determine the relative recidivism risk of these two groups, and to find factors which were significant predictors of recidivism for all DUI convictees.

Test status (refusals versus test-takers) was significant and the associated odds ratio indicated that BAC refusals were 22.7% more likely to recidivate than BAC test-takers. Other significant findings among all DUI convictees (this analysis included both BAC test-takers and refusals) were increases in the odds of recidivating of 10.0% for each prior 2-year total conviction, 34.3% for each prior 2-year DUI conviction, 54.5% for male versus female gender and 27.5% for each prior 2-year HBD accident. The odds of recidivating decreased by 40.2% (1 - 0.598) if the reference event involved an accident, and by 0.5% for each one year increase in age. The final model, containing only significant predictors of subsequent 1-year DUI events, is shown in Table 4.

Table 4

Logistic Regression Model for BAC-Tested and Refusal Convictees, Main Effects

Variables	Chi-square at entry	Entry sequence	Wald chi square at end	Pr > chi-square	Final regression coefficients	Odds ratios
Intercept	------	------	840.7825	0.0001	-3.6895	0.025
2-year total convictions	236.1	1	85.6826	0.0001	0.0957	1.100
2-year DUI convictions	112.2	2	80.6225	0.0001	0.2950	1.343
Gender	64.7008	3	59.8931	0.0001	0.4349	1.545
Reference event an accident	31.0645	4	36.2017	0.0001	-0.5148	0.598
Test status	15.4393	5	16.7710	0.0001	0.2043	1.227
2-year HBD accidents	12.4287	6	12.2362	0.0005	0.2432	1.275
Age	7.5896	7	7.5872	0.0059	-0.00453	0.995

-2 Log *L* for intercept = 29384.760; -2 Log *L* for intercept and covariates = 28938.410; chi-square for covariates = 449.350, $df = 7$, $p = 0.0001$

Recidivism as a Function of Offender Level for BAC Refusals. Beginning with the final model obtained for the BAC-tested convictees, but excluding BAC, BAC^2 and BAC^3 (because these factors were not available for BAC refusals), iterative logistic regression analyses were performed as described earlier to compare first and repeat offenders who refused BAC testing. This was done in order to determine the relative risk of recidivating of these two groups, and to find factors which were significant predictors of recidivism for DUI convictees who refused BAC testing.

Offender level (repeat offenders who refused versus first offenders who refused) was significant and showed that repeat offenders who refused BAC testing were 29.5% more likely to recidivate than were first offenders who refused BAC testing. Each prior 2-year total conviction increased the odds of recidivating by 30.8% among BAC refusals. In addition, if the reference event was an accident there was a decrease of 25.8% (1 - 0.742) in the likelihood of recidivism. The final model, containing only significant predictors of subsequent 1-year DUI events, is presented in Table 5.

Table 5

Logistic Regression Model for BAC-Refusal Convictees, Main Effects

Variables	Chi-square at entry	Entry sequence	Wald chi-square at end	Pr > chi-square	Final regression coefficients	Odds ratios
Intercept	------	------	587.2661	0.0001	-2.6635	0.070
2-year DUI convictions	23.2097	1	10.1166	0.0015	0.2588	1.295
Offender level	6.8580	2	6.7493	0.0094	0.2686	1.308
Reference event an accident	4.3144	3	4.2861	0.0384	-0.2991	0.742

-2 Log *L* for intercept = 3400.629; -2 Log *L* for intercept and covariates = 3368.218; chi-square for covariates = 32.411, $df = 3$, $p = 0.0001$

Increase in Odds of Recidivism of: (1) Repeat Versus First Offense and (2) Refusing Versus Taking BAC Test. When all other factors are held constant, the relationship between first and repeat offenders for BAC test-takers and refusers can be determined. For BAC-tested offenders, repeat offenders had 14.8% greater probability of recidivating than did first offenders, while offenders who refused BAC testing had 22.7% greater probability of recidivating than those who agreed to be tested. Refusals had 29.0% greater probability of recidivating than first offenders who were BAC-tested, but were not significantly different than repeat offenders who were BAC-tested. Among those who refused testing, repeat offenders had a 30.8% greater probability of recidivating than first offenders.

<u>**Logistic Regression Model Predicting Subsequent 1-Year DUI Recidivism: Complex Model, Main Effects and 2-Way Interactions**</u>

BAC-Tested Convictees. This analysis began with the 10 main effects found to be significant in the main effects model for BAC-tested convictees. This was done in order to enable comparisons with the main effects models and allow the effects of the interactions to be evaluated relative to models just consisting of main effects. Studies using logistic regression rarely include interaction terms, so the usefulness of these terms needed to be explored.

As for the main effects models, DUI convictees who agreed to BAC testing were analyzed as described earlier in order to determine the relative risk of recidivating of first and repeat offenders who agreed to be tested, and to find factors which were significant predictors of recidivism for these drivers.

Later models involving 2-way interactions were employed and all 2-way interaction combinations of the 10 main effects were included in the initial model, except for those that would have involved the BAC^2 and BAC^3 factors. Thus, the initial interaction model involved 10 main effects and 28 2-way interactions. Five iterations of logistic regressions, with nonsignificant factors being removed after each, resulted in the final equation which contained 10 main effects and four 2-way interactions, for a total of 14 significant factors.

Among DUI convictees who agreed to BAC testing in the interaction model, the odds of recidivating increased by 13.4% for each prior 2-year total conviction, 79.8% for each prior 2-year DUI conviction, 32.5% for each prior 2-year HBD accident, 55.4% for male versus female gender, 89.7% for repeat versus first offenders and 1.3% for each unit increase in the interaction between age and offender level. The odds of recidivating decreased by 45.2% if the reference event was an accident, by 1.4% for each one year increase in age, by 92.8% for each unit increase in the interaction between BAC and offender level, by 96.4% for each unit increase in the interaction between BAC and prior 2-year HBD accidents and by 36.7% for each unit increase in the interaction between prior 2-year DUI convictions and offender level. The final model is shown in Table 6.

Table 6

Logistic Regression Model for BAC-Tested Convictees, Main Effects and 2-Way Interactions

Variables	Chi-square at entry	Entry sequence	Wald chi-square at end	Pr > chi-square	Final regression coefficients	Odds ratios
Intercept	------	------	209.3149	0.0001	-3.5824	0.028
2-year total convictions	227.6	1	128.1331	0.0001	0.1253	1.134
BAC^2	188.8	2	49.3322	0.0001	112.5	*
Gender	67.7066	3	52.9366	0.0001	0.4408	1.554
2-year DUI convictions	54.1799	4	22.9826	0.0001	0.5865	1.798
Reference event an accident	46.9593	5	41.7508	0.0001	-0.6011	0.548
BAC^3	22.1822	6	40.4843	0.0001	-179.5	*
BAC	33.9995	7	27.9531	0.0001	-15.2973	*
Age	19.7880	8	34.7990	0.0001	-0.0138	0.986
Age x offender level	17.9445	9	13.2044	0.0003	0.0131	1.013
BAC x offender level	24.2706	10	18.6147	0.0001	-2.6330	0.072
2-year HBD accidents	9.0296	11	35.2167	0.0001	0.8439	2.325
BAC x 2-year HBD accidents	24.4078	12	23.8230	0.0001	-3.3310	0.036
2-year DUI convictions x offender Level	3.6056	13	12.7166	0.0004	-0.4575	0.633
Offender level	10.1234	14	10.1295	0.0015	0.6403	1.897

-2 Log *L* for intercept = 25958.771; -2 Log *L* for intercept and covariates = 25251.567; chi-square for covariates = 707.204, $df = 14$, $p = 0.0001$

*The overall odds ratios for BAC, BAC^2, and BAC^3 reflect the high degree of collinearity inherent in polynomial components. The best way to determine the odds ratio for BAC is to use the three polynomial terms as a set to predict rates of recidivism for specific pairs of BAC levels, holding all other factors constant. For example, for a 30-year old man convicted of his first DUI with no prior accidents or convictions of any type on his driving record, the odds of recidivating with BACs of 0.20% and 0.30%, relative to a BAC of 0.10%, are 1.735 and 3.180, respectively.

Recidivism as a Function of BAC Test Status (Tested Versus Refused). Beginning with the final main effects and 2-way interactions model obtained for the BAC-tested convictees, but excluding BAC, BAC^2, and BAC^3 (because these factors were not available for BAC refusals), iterative logistic regression analyses were performed on all DUI convictees to compare BAC test-takers to BAC refusals. As with the main effects model, this was done to determine the relative risk of these two groups, and to find factors which were significant predictors of recidivism for all DUI convictees.

Test status (refusals versus test-takers) was not a significant factor in this model, but factors related to offender level, such as prior 2-year DUI convictions, were. The presence of 2-way interactions in the modeling procedure caused test status to drop out due to nonsignificance at one of the iterations in the development of the final model. In the final model the odds of recidivating were increased by 10.2% for each prior 2-year total conviction, 35.4% for each prior 2-year DUI conviction, 54.9% for male versus female gender and 27.6% for each prior 2-year HBD accident. The odds of recidivating were decreased by 40.3% if the reference event was an accident and by 0.4% for each year of age. The final model, containing only significant predictors of subsequent 1-year DUI events, is presented in Table 7.

Table 7

Logistic Regression Model for BAC-Tested and Refusal Convictees,
Main Effects and 2-Way Interactions Model

Variables	Chi-square at entry	Entry sequence	Wald chi-square at end	Pr > chi-square	Final regression coefficients	Odds ratios
Intercept	------	------	845.7279	0.0001	-3.6976	0.025
2-year total convictions	236.1	1	87.8876	0.0001	0.0968	1.102
2-year DUI convictions	112.2	2	85.1645	0.0001	0.3027	1.354
Gender	64.7008	3	60.5962	0.0001	0.4374	1.549
Reference event an accident	31.0645	4	36.3443	0.0001	-0.5163	0.597
2-year HBD accidents	12.4930	5	12.3155	0.0001	0.2441	1.276
Age	6.2587	6	6.2571	0.0124	-0.0041	0.996

-2 Log L for intercept = 29384.760; -2 Log L for intercept and covariates = 28951.515; chi-square for covariates = 433.245, $df = 6$, $p < 0.0001$

Recidivism as a Function of Offender Level for BAC Refusals. Beginning with the final model obtained for the BAC-tested convictees, but excluding BAC, BAC^2, and BAC^3 (because these factors were not available for BAC refusals), iterative logistic regression analyses were performed on first and repeat offenders who refused BAC testing. As with the main effects model, this was done in order to determine the relative risk of recidivating of these two groups, and to find factors which were significant predictors of recidivism for DUI convictees who refused BAC testing.

The number of prior 2-year DUI convictions was significant, with each conviction increasing the odds of recidivism by 41.9%. If the reference event was an accident, the likelihood of recidivating decreased by 26% (1 - 0.740). Offender level was not significant and was deleted from the final equation. Again, this did not occur in the main effects only model and is the result of the introduction of 2-way interaction terms. However, offender level is directly related to the number of prior 2-year DUI convictions as first offenders would have only one, while repeat offenders would have two or more. The final model, containing only significant predictors of subsequent 1-year DUI events, is shown in Table 8.

Table 8

Logistic Regression Model for BAC-Refusal Convictees, Main Effects and 2-Way Interactions

Variables	Chi-square at entry	Entry sequence	Wald chi-square at end	Pr > chi-square	Final regression coefficients	Odds ratios
Intercept	------	------	628.1002	0.0001	-2.6730	0.069
2-year DUI convictions	23.2097	1	22.7311	0.0001	0.3501	1.419
Reference event an accident	4.3903	2	4.3610	0.0368	-0.3015	0.740

-2 Log L for intercept = 3400.629; -2 Log L for intercept and covariates = 3374.964; chi-square for covariates = 25.666, $df = 2$, $p < 0.0001$

Increase in Odds of Recidivism of: (1) Repeat Versus First Offense and (2) Refusing Versus Taking BAC Test. When all other factors are held constant, the relationship between first and repeat offenders for BAC test-takers and refusers can be determined. For BAC-tested offenders, repeat offenders had an 89.7% greater probability of recidivating than did first offenders. Offenders who refused BAC testing had no greater probability of recidivating than those who agreed to be tested, but each prior 2-year DUI conviction increased the probability of recidivism by 34.5%. Refusers had a 127.9% greater probability of recidivating than first offenders who were BAC-tested, but were not significantly different than repeat offenders who were BAC-tested. For those who refused testing, repeat offenders had no greater probability of recidivating than first offenders, but each prior 2-year DUI conviction increased the probability of recidivism by 41.9%.

<u>Comparison of Main Effects Only and Main Effects Plus 2-Way Interaction Complex Logistic Regression Models</u>

No analyses of factors beyond 2-way interactions were performed because of the difficulty in interpreting the meaning of significant higher order interactions and the limitation of available computer resources to perform such memory intensive and time demanding analyses. Some factors were found in both main effects and main effects plus 2-way interaction models, while others were found only in one.

For the analyses of the BAC-tested DUI convictees, the 10 main effects that were significant in the main effects model were also significant in the main effects plus 2-way interactions model, which had four additional significant interaction terms. In the analyses of the BAC-tested versus the BAC-refusal DUI convictees (i.e., all DUI convictees), six of the seven factors found in the main effects model were found in the main effects plus 2-way interactions model and one was not. For the analyses of the BAC refusal DUI convictees, two factors were common to both models and one was not.

Table 9 summarizes the factors found in one or both models. All the factors in a model can be determined by including those in the "both models" column with those in the "only" model column of interest.

Table 9

Comparison of Significant Factors in Main Effects and Main Effects Plus 2-Way Interaction Models

	Factors only in main effects model	Factors in both models	Factors only in main effects plus 2-way interaction model
BAC-tested	----------	(1) 2-year total convictions (2) BAC (3) BAC^2 (4) BAC^3 (5) Gender (6) 2-year DUI convictions (7) Reference event an accident (8) Age (9) Offender level (10) 2-year HBD accidents	(1) Age x offender level (2) BAC x offender level (3) BAC x 2-year HBD accidents (4) 2-year DUI convictions x offender level
BAC-tested vs. BAC - refusal	(1) Test status*	(1) 2-year total convictions (2) 2-year DUI convictions (3) Gender (4) Reference event an accident (5) Age (6) 2-year HBD accidents	----------
BAC-refusal	(1) Offender level*	(1) 2-year DUI convictions (2) Reference event an accident	

*Test status and offender level were significant in the main effects model and not in the main effect plus 2-way interaction model because a sequential analysis, which enters all variables at the same time into the equation, was used in this study. If a hierarchical analysis, which enters all main effects into the equation before any interactions are entered, had been used then test status and offender level would have been a significant factor in both models.

Logistic Regression Models Predicting Subsequent 1-Year DUI Recidivism for BAC-Tested DUI Convictees: Simple Main Effects Models for Practical Application

For a model to have its greatest practical utility, it should not be too arcane for nontechnical users to understand. In general, the widest application of models, such as the types being developed in this study, would be expected to occur when a large number of potential users of the findings understand the rationale and components of the model and, hence, the meaning of the findings.

The complex logistic regression models presented previously have many factors, which mitigates against their widespread use in an applied setting. Therefore, models were developed which included BAC and which have only a few factors. These models can be readily understood by nonresearchers and the findings that they generate can be easily comprehended by users. Since all of these models have BAC as a factor, they do not include convictees who refused BAC testing or comparisons involving BAC refusal groups. The findings of the complex main effects models are used for these groups.

Main effects models were developed which focused on BAC-tested DUI convictees, thus allowing BAC level to be a factor. Age and gender were excluded from the models because DUI sanctions cannot legally be based on age or gender. Two models were developed using significant factors drawn from the complex models developed earlier. The first model used offender level (first or repeat offender) along with BAC, BAC^2, and BAC^3 to determine risk, while the second used offender level and prior 2-year total convictions along with BAC, BAC^2, and BAC^3.

Main Effects Model Using BAC and Offender Level (First or Repeat Offense). The model using BAC, BAC^2, BAC^3, and offender level (first or repeat offense) was obtained with the events/trials model syntax. Table 10 shows the final model containing significant factors. Repeat offenders were 35.4% more likely to recidivate than were first offenders. The odds of recidivating for BAC are discussed in the footnote to the table.

Table 10

Logistic Regression Model: BAC, BAC^2, BAC^3, and Offender Level (Simple Two Factor Model)

Variables	Chi-square at entry	Entry sequence	Wald chi-square at end	Pr > chi-square	Final regression coefficients	Odds ratios
Intercept	------	------	158.3300	0.0001	-2.1053	0.122
BAC^2	145.6	1	42.1744	0.0001	114.0	*
Offender level	78.6066	2	73.0384	0.0001	0.3033	1.354
BAC^3	9.8291	3	37.7580	0.0001	-198.1	*
BAC	31.4421	4	30.7164	0.0001	-16.6352	*

-2 log *L* for intercept = 25958.771; -2 log *L* for intercept and covariates = 25711.051; chi-square for covariates = 247.720, $df = 4$, $p = 0.0001$

*The overall odds ratios for BAC, BAC^2, and BAC^3 reflect the high degree of collinearity inherent in polynomial components. The best way to determine the odds ratio for BAC is to use the three polynomial terms as a set to predict rates of recidivism for specific pairs of BAC levels, holding all other factors constant. For example, for a 30-year old man convicted of his first DUI with no prior accidents or convictions of any type on his driving record, the odds of recidivating with BACs of 0.20% and 0.30%, relative to a BAC of 0.10%, are 1.412 and 1.810, respectively.

The probabilities of recidivism predicted by this model are presented in Table 11. Surprisingly, the maximum predicted rate of recidivism for both first and repeat offenders is at a BAC of 0.00%. The minimum predicted rates for both groups of offenders is at a BAC of 0.10%, and the maximum predicted rates for positive BAC levels for both groups is at a BAC of 0.29%.

Table 11

Recidivism Predicted by BAC, BAC^2, BAC^3, and Offender Level

BAC	First offenders	Repeat offenders
0.00%	0.109	0.142
0.01%	0.095	0.124
0.02%	0.084	0.110
0.03%	0.075	0.099
0.04%	0.069	0.091
0.05%	0.064	0.085
0.06%	0.061	0.081
0.07%	0.059	0.078
0.08%	0.057	0.076
0.09%	0.056	0.074
0.10%	0.056	0.074
0.11%	0.056	0.075
0.12%	0.057	0.076
0.13%	0.059	0.078
0.14%	0.060	0.080
0.15%	0.063	0.083
0.16%	0.065	0.087
0.17%	0.068	0.090
0.18%	0.072	0.095
0.19%	0.075	0.099
0.20%	0.079	0.104
0.21%	0.083	0.109
0.22%	0.086	0.114
0.23%	0.090	0.118
0.24%	0.094	0.123
0.25%	0.097	0.127
0.26%	0.099	0.130
0.27%	0.101	0.132
0.28%	0.102	0.133
0.29%	0.102	0.133
0.30%	0.101	0.132
0.31%	0.099	0.129
0.32%	0.096	0.125
0.33%	0.091	0.119
0.34%	0.085	0.112
0.35% plus	0.079	0.104

Graphs of the predicted probabilities and 95% confidence limits of recidivism for first and repeat offenders are shown in Figures 5 and 6.

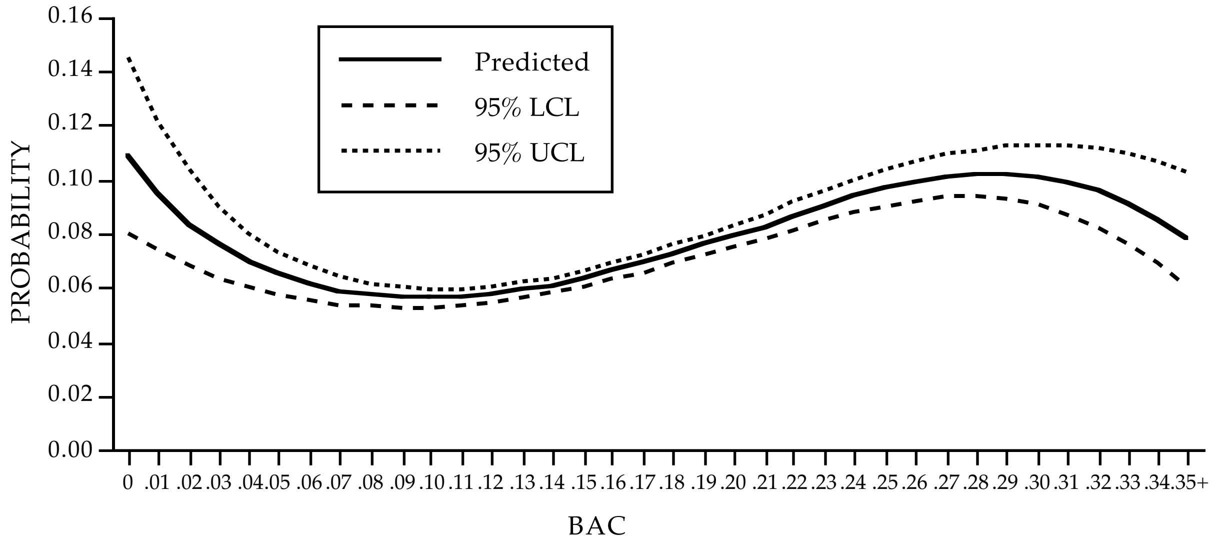
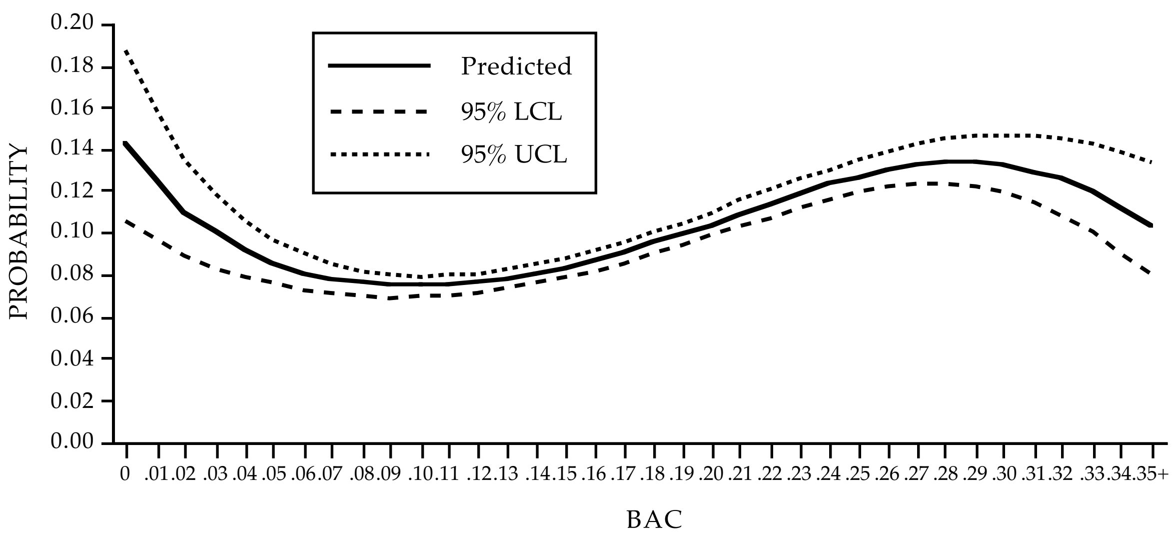


Figure 5. Predicted probabilities of DUI recidivism based on BAC, BAC^2, and BAC^3 for first offenders.



Note: LCL = lower confidence limit and UCL = upper confidence limit.

Figure 6. Predicted probabilities of DUI recidivism based on BAC, BAC^2, and BAC^3 for repeat offenders.

Main Effects Model Using BAC, Prior 2-Year Total Convictions, and Offender Level. The model obtained using BAC, BAC^2, BAC^3, prior 2-year total convictions and offender level (first or repeat offense) is shown in Table 12. The single most powerful predictor of recidivism was the number of total convictions in the prior two years, as evidenced by the entry sequence and chi square values. Each prior 2-year total conviction increased the odds of recidivating by 20.6%, while repeat offenders were 25.3% more likely to recidivate than were first offenders. The odds of recidivating for BAC are discussed in the footnote to the table.

Table 12

Logistic Regression Model: BAC, BAC^2, BAC^3, Prior 2-Year Total Convictions, and Offender Level (Simple Three Factor Model)

Variables	Chi-square at entry	Entry sequence	Wald chi-square at end	Pr > chi-square	Final regression coefficients	Odds ratios
Intercept	------	------	228.9304	0.0001	-2.5937	0.075
2-year Total Convictions	218.5	1	235.8805	0.0001	0.1876	1.206
BAC^2	199.8	2	45.5434	0.0001	118.9	*
Offender Level	43.7496	3	39.2197	0.0001	0.2252	1.253
BAC^3	15.5567	4	41.5454	0.0001	-208.7	*
BAC	30.8867	5	30.1647	0.0001	-16.5501	*

-2 Log *L* for intercept = 25958.771; -2 Log *L* for intercept and covariates = 25490.090; chi-square for covariates = 468.682, *df* = 5, *p* = 0.0001

*The overall odds ratios for BAC, BAC^2, and BAC^3 reflect the high degree of collinearity inherent in polynomial components. The best way to determine the odds ratio for BAC is to use the three polynomial terms as a set to predict rates of recidivism for specific pairs of BAC levels, holding all other factors constant. For example, for a 30-year old man convicted of his first DUI with no prior accidents or convictions of any type on his driving record, the odds of recidivating with BACs of 0.20% and 0.30%, relative to a BAC of 0.10%, are 1.532 and 2.066, respectively.

The probabilities of recidivism predicted from the model equation for first and repeat offenders are shown in Tables 13 and 14 for combinations of BAC level and prior 2-year total convictions that were observed[3]. Within each BAC level, increasing numbers of prior 2-year total convictions lead to predictions of increasingly higher rates of recidivism. In fact, the rate of recidivism is often predicted to be greater for a BAC level with many prior 2-year total convictions than for a higher BAC level with few prior 2-year total convictions.

For first time DUI convictees, the minimum predicted reoffense rate was 0.0438 for a BAC of 0.09% for drivers with no prior convictions. For repeat offenders, the lowest reoffense rate (mean = 0.0542) was also predicted for offenders with BACs of 0.09% and no traffic convictions in the 2 years prior to the reference DUI.

[3] The event/total syntax of PROC LOGISTIC in SAS outputs the values of predicted dependent variables for each combination of independent variables used in the prediction. Predicted values for combinations of independent variables not used in the prediction can be estimated using the model equation.

Table 13

Recidivism Predicted by BAC, BAC^2, BAC^3, and Prior 2-Year Total Convictions for First Offenders

BAC	Prior 2-year total convictions*					
	0	1	2	3	4	5+
0.00	0.0827	0.0981	0.1160	0.1366	0.1603	0.1872
0.01	0.0718	0.0853	0.1011	0.1195	0.1450[e]	0.1649
0.02	0.0635	0.0756	0.0898	0.1064	0.1290[e]	0.1514[e]
0.03	0.0573	0.0683	0.0812	0.0963	0.1140	0.1378[e]
0.04	0.0526	0.0628	0.0747	0.0888	0.1052	0.1242
0.05	0.0492	0.0587	0.0670	0.0832	0.0987	0.1167
0.06	0.0467	0.0558	0.0666	0.0792	0.0940	0.1112
0.07	0.0451	0.0539	0.0643	0.0765	0.0909	0.1076
0.08	0.0441	0.0527	0.0629	0.0749	0.0890	0.1055
0.09	0.0438	0.0523	0.0624	0.0744	0.0883	0.1046
0.10	0.0439	0.0525	0.0627	0.0746	0.0886	0.1050
0.11	0.0446	0.0533	0.0636	0.0757	0.0899	0.1065
0.12	0.0456	0.0545	0.0651	0.0775	0.0920	0.1089
0.13	0.0471	0.0563	0.0672	0.0799	0.0948	0.1122
0.14	0.0490	0.0586	0.0698	0.0830	0.0985	0.1164
0.15	0.0513	0.0613	0.0730	0.0867	0.1028	0.1214
0.16	0.0539	0.0644	0.0766	0.0910	0.1077	0.1271
0.17	0.0569	0.0678	0.0807	0.0958	0.1133	0.1335
0.18	0.0601	0.0717	0.0852	0.1010	0.1193	0.1405
0.19	0.0636	0.0758	0.0900	0.1066	0.1258	0.1479
0.20	0.0673	0.0801	0.0951	0.1125	0.1326	0.1557
0.21	0.0711	0.0846	0.1003	0.1185	0.1395	0.1636
0.22	0.0749	0.0890	0.1055	0.1245	0.1464	0.1715
0.23	0.0787	0.0934	0.1105	0.1304	0.1531	0.1791
0.24	0.0822	0.0975	0.1153	0.1359	0.1594	0.1862
0.25	0.0854	0.1012	0.1196	0.1408	0.1651	0.1925
0.26	0.0881	0.1043	0.1232	0.1449	0.1698	0.1979
0.27	0.0901	0.1067	0.1260	0.1481	0.1733	0.2019
0.28	0.0914	0.1082	0.1276	0.1500	0.1755	0.2035
0.29	0.0917	0.1085	0.1281	0.1505	0.1761	0.2050
0.30	0.0909	0.1077	0.1271	0.1494	0.1729[e]	0.2035[e]
0.31	0.0891	0.1056	0.1246	0.1466	0.1696[e]	0.1999
0.32	0.0861	0.1021	0.1206	0.1419	0.1663	0.1928[e]
0.33	0.0820	0.0972	0.1150	0.1355	0.1590[e]	0.1857
0.34	0.0768	0.0912	0.1079	0.1274	0.1450[e]	0.1730[e]
0.35+	0.0706	0.0840	0.0996	0.1177	0.1350[e]	0.1610[e]

*Conviction count does not include reference conviction.

[e]Extrapolated value.

Table 14

Recidivism Predicted by BAC, BAC^2, BAC^3, and Prior 2-Year Total Convictions for Repeat Offenders

	Prior 2-year total convictions*					
BAC	0	1	2	3	4	5+
0.00	0.1015	0.1199	0.1412	0.1655	0.193	0.2239
0.01	0.0883	0.1046	0.1235	0.1453	0.1702	0.2035[e]
0.02	0.0783	0.0929	0.1116[e]	0.1297	0.1524	0.1831[e]
0.03	0.0707	0.0841	0.0997	0.1178	0.1418[e]	0.1627
0.04	0.0658[e]	0.0774	0.0919	0.1088	0.1312[e]	0.1523[e]
0.05	0.0608	0.0725	0.0861	0.1021	0.1206	0.1419
0.06	0.0578	0.0689	0.082	0.0973	0.115	0.1355
0.07	0.0558	0.0666	0.0792	0.094	0.1113	0.1312
0.08	0.0547	0.0652	0.0776	0.0921	0.1091	0.1287
0.09	0.0542	0.0647	0.077	0.0914	0.1082	0.1277
0.10	0.0544	0.0649	0.0773	0.0917	0.1086	0.1281
0.11	0.0552	0.0658	0.0784	0.093	0.1101	0.1298
0.12	0.0565	0.0674	0.0802	0.0952	0.1126	0.1327
0.13	0.0584	0.0696	0.0827	0.0981	0.116	0.1367
0.14	0.0607	0.0723	0.0859	0.1018	0.1203	0.1416
0.15	0.0635	0.0756	0.0897	0.1063	0.1255	0.1475
0.16	0.0667	0.0793	0.0941	0.1114	0.1314	0.1543
0.17	0.0703	0.0835	0.0991	0.1171	0.138	0.1618
0.18	0.0742	0.0882	0.1045	0.1234	0.145	0.17
0.19	0.0785	0.0931	0.1102	0.13	0.1527	0.1786
0.20	0.0829	0.0983	0.1163	0.137	0.1607	0.1876
0.21	0.0875	0.1037	0.1225	0.1441	0.1688	0.1968
0.22	0.0921	0.1091	0.1287	0.1512	0.1769	0.2059
0.23	0.0966	0.1143	0.1347	0.1581	0.1847	0.2146
0.24	0.1009	0.1192	0.1403	0.1645	0.192	0.2227
0.25	0.1047	0.1236	0.1454	0.1703	0.1985	0.23
0.26	0.108	0.1273	0.1497	0.1752	0.2039	0.2361
0.27	0.1104	0.1302	0.1529	0.1788	0.208	0.2406
0.28	0.1118	0.1319	0.1549	0.181	0.2105	0.2434
0.29	0.1122	0.1323	0.1554	0.1816	0.2112	0.2441
0.30	0.1114	0.1313	0.1542	0.1803	0.2097	0.2425
0.31	0.1092	0.1288	0.1513	0.177	0.2048[e]	0.2384
0.32	0.1056	0.1246	0.1466	0.1716	0.1999	0.2316
0.33	0.1006	0.1189	0.14	0.1641	0.1915	0.2222
0.34	0.0943	0.1116	0.1316	0.1546	0.1807	0.2089[e]
0.35+	0.0869	0.103	0.1216	0.1431	0.1677	0.1956

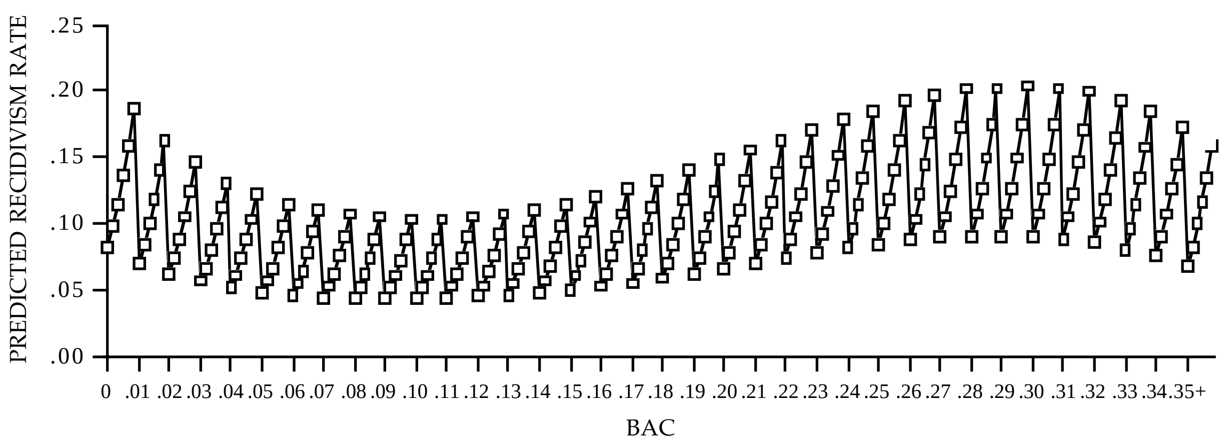
* Conviction count does not include reference conviction.
[e]Extrapolated value.

For first time DUI convictees with a BAC of 0.00% and five or more prior 2-year total convictions, the predicted rate of recidivism was 0.1872, compared to the 0.00% BAC first offense group overall mean of 0.1302. The highest predicted rate of recidivism for a positive BAC level was 0.2050 for a BAC of 0.29% with five or more prior 2-year total convictions, compared to the group mean of 0.1433 for all convictees with a BAC level of 0.29%.

For repeat offenders with a BAC of 0.00% and five or more prior 2-year total convictions, the predicted rate of recidivism was 0.2239, compared to the 0.00% BAC repeat offense group mean of 0.1575. The highest predicted rate of recidivism for a positive BAC level was 0.2441 for a BAC of 0.29% with nine prior 2-year total convictions, compared to the group mean of 0.1728 for a BAC of 0.29%.

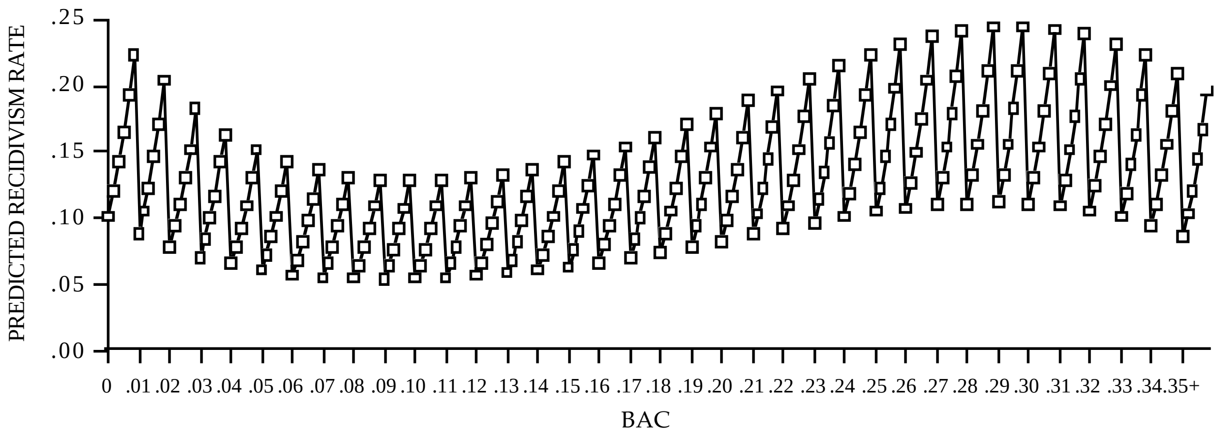
The inclusion of prior 2-year total convictions as a factor results in a much wider range of predicted recidivism for both first and repeat offenders because drivers are subdivided into more disparate groups on a variable which has the strongest relationship to the probability of reoffending. Tables 13 and 14 present the details of these predicted rates.

Graphs of the predicted probabilities of recidivism for first and repeat offenders found in Tables 13 and 14 are shown in Figures 7 and 8. The saw-toothed pattern of the graphs reflects the increased probability of recidivism for increasing numbers of prior 2-year total convictions within each BAC level.



Note. Each BAC level has six points associated with it indicating predicted recidivism rates for DUI convictees with 0 to 5+ (reading left to right within each BAC level) prior 2-year total convictions.

Figure 7. Predicted probabilities of DUI recidivism based on BAC, BAC^2, BAC^3, and 2-year prior total convictions for first offenders.



Note. Each BAC level has six points associated with it indicating predicted recidivism rates for DUI convictees with 0 to 5+ (reading left to right within each BAC level) prior 2-year total convictions.

Figure 8. Predicted probabilities of DUI recidivism based on BAC, BAC^2, BAC^3, and 2-year prior total convictions for repeat offenders.

Relative Predictive Power of All Models Using BAC-Tested DUI Convictees. Different models for BAC-tested DUI convictees were compared using the Akaike Information Criterion (AIC)[4] which adjusts the -2 Log Likelihood statistic for the number of terms in the model and the number of observations used. AIC values for models containing predictive factors are shown in Table 15 along with the value for the intercept alone model (zero slope). Lower values indicate a better fit.

Table 15

Comparison of Model Fit for Models Involving BAC-Tested Convictees Using the Akaike Information Criterion (AIC)

Model	AIC value	Rank as to fit
Intercept only	25960.771	------
Intercept + factors		
Complex: 10 main effects + four 2-way interactions	25281.567	1
Complex: 10 main effects	25342.759	2
Simple: three factors	25502.090	3
Simple: two factors	25721.051	4

As expected, the more factors in the model, the better the fit.

[4] AIC = -2 Log L + 2(k + s), where k = number of ordered values for the response and s = number of explanatory variables

Use of Simple Main Effects Models to Classify DUI Convictees with BAC Levels as Being of High Risk to Recidivate. The models predict recidivism along a continuum, without a break that marks a clear separation of DUI convictees with a high risk to recidivate from those with a low risk to recidivate. However, the degree of risk for any designated group of convictees can be stated in relative terms so that it can be compared to all other groups of convictees.

For the model based on BAC, BAC^2, BAC^3, and offender level, the predicted rates (probabilities) of recidivism as calculated from the logistic regression model can be grouped into deciles (every 10th percentile) and related to BAC levels. The rate of recidivism at each tenth percentile is shown in Table 16 for first and repeat offenders. Also shown for each tenth percentile is the lowest BAC level (among per se illegal values of 0.08% or greater) with an equal or greater predicted rate of recidivism than found at the percentile.

For the percentiles shown, BAC levels of repeat offenders tend to be slightly higher than BAC levels of first offenders (generally 0.01 to 0.02% higher) but the actual predicted rates of recidivism for repeat offenders are much higher (mean = 1.3922 times greater, range = 1.3329 to 1.4505 times greater). Thus, repeat offenders have only slightly higher BAC levels than first offenders, but recidivate at a much higher rate than first offenders.

Table 16

Rates of Recidivism at Each Tenth Percentile Predicted by BAC, BAC^2, BAC^3, and Offender Level with Lowest BAC Level (0.08% or Greater) Having an Equal or Higher Rate of Recidivism

Percentile	First offender		Repeat offender	
	Rate of recidivism at percentile	Lowest BAC level with predicted recidivism rate equal or greater than percentile	Rate of recidivism at percentile	Lowest BAC level with predicted recidivism rate equal or greater than percentile
10	0.0561	0.09%	0.0747	0.08% & 0.11%
20	0.0569	0.08% & 0.12%	0.0759	0.12%
30	0.0586	0.13%	0.0801	0.14%
40	0.0604	0.14%	0.0831	0.15%
50	0.0627	0.15%	0.0904	0.17%
60	0.0683	0.17%	0.0946	0.18%
70	0.0716	0.18%	0.1039	0.20%
80	0.0789	0.20%	0.1136	0.22%
90	0.0901	0.23%	0.1265	0.25%

This table is read first by determining whether a convictee is a first or repeat offender and then what the BAC level is. For example, if a convictee is a first offender with a BAC level of 0.14%, then that individual falls above the 40th percentile level (but below the 50th percentile) which has a rate of recidivism of 0.0604. Another example would be a convictee who is a repeat offender with a BAC level of 0.27%. This convictee would fall above the 90th percentile level, as all repeat offenders with a BAC level of 0.25% or greater do. The rate of recidivism for the 90th percentile repeat offenders is 0.1265.

The model based on BAC, BAC^2, BAC^3, offender level, and prior 2-year total convictions makes more complex predictions of recidivism, as shown in the saw-toothed graphs in Figures 7 and 8. Percentile rates of recidivism do not correspond to unique BAC levels alone, but to combinations of BAC level and number of prior 2-year total convictions. Rates of recidivism for each tenth percentile, along with combinations of BAC level and number of prior 2-year total convictions that have higher recidivism rates than each percentile for this model, are shown in Table 17 for first offenders and in Table 18 for repeat offenders.

The tables show that drivers convicted of DUI at any BAC level could be in different percentiles, depending on their number of prior 2-year total convictions. Drivers in the group with a BAC of 0.09% and no prior 2-year total convictions preceding the reference conviction have the lowest predicted rate of recidivism for both first and repeat offenders. As BAC decreases and increases, and as the number of prior 2-year total convictions increases from this group, there is an increase in the percentile with which the groups are associated. The groups in the highest percentiles have either very high or very low BAC levels, many prior 2-year total convictions, or moderate to high values for both.

While many cells show the 90th percentile, each of these cells generally had few observations. Percentiles with few cells, such as the 20th percentile, generally had a relatively large number of observations in each cell. The total observations associated with each tenth percentile equals 10 percent of all subjects.
Both tables show similar patterns in the rate of recidivism by percentiles, with minimums at a BAC level of 0.09% and no prior 2-year total convictions. As one scans up, down or to the right of this cell, there is an increase in percentile of the groups. For first offenders, all cells with five or more prior 2-year total convictions, are above the 90th percentile in recidivism. For repeat offenders, all cells with five or more prior 2-year total convictions are above the 90th percentile in recidivism, except at BACs of 0.07 to 0.11, where all cells with five or more prior 2-year total convictions are above the 80th percentile.

Finally, the increase in percentiles can be seen as radiating out from the BAC level 0.09% and no prior 2-year total convictions cell. With the exception of some of the highest BAC level cells with few 2-year total convictions, the increase is monotonic in all directions in the tables. The percentile in which a driver falls can be compared to percentiles of other BAC levels with the same number of 2-year total convictions, of the same BAC level with other prior 2-year total conviction counts, or of different combinations of BAC levels and prior 2-year total conviction counts.

An example from Table 17 for first offenders would be a convictee with a BAC of 0.15% with no prior 2-year total convictions. This individual would be above the 10th percentile (i.e., in the 10th to 19th percentile) to recidivate. Another individual with the same BAC level, but with three prior 2-year total convictions, would be above the 80th percentile (i.e., in the 80th to 89th percentile) to recidivate.

Table 17

Combinations of BAC Level and Number of Prior 2-Year Total Convictions Leading to Relative Recidivism Rates Equal to or Higher Than Each Tenth Percentile Predicted by BAC, BAC^2, BAC^3, and Prior 2-Year Total Convictions: For First Offenders

	Prior 2-year total convictions*					
BAC	0	1	2	3	4	5+
0.00	80	90	90	90	90	90
0.01	60	80	90	90	90[a]	90
0.02	50	70	80	90	90[a]	90[a]
0.03	30	60	70	80	90	90[a]
0.04	20	50	70	80	90	90
0.05	10	40	50	80	80	90
0.06	10	30	50	70	80	90
0.07	0[b]	20	50	70	80	90
0.08	0[b]	20	50	70	80	90
0.09	0[b]	20	50	60	80	90
0.10	0[b]	20	50	60	80	90
0.11	0[b]	20	50	70	80	90
0.12	0[b]	30	50	70	80	90
0.13	10	30	50	70	90	90
0.14	10	40	60	80	90	90
0.15	10	40	60	80	90	90
0.16	20	50	70	80	90	90
0.17	30	50	70	90	90	90
0.18	40	60	80	90	90	90
0.19	50	70	80	90	90	90
0.20	50	70	90	90	90	90
0.21	60	80	90	90	90	90
0.22	70	80	90	90	90	90
0.23	70	90	90	90	90	90
0.24	70	90	90	90	90	90
0.25	80	90	90	90	90	90
0.26	80	90	90	90	90	90
0.27	80	90	90	90	90	90
0.28	80	90	90	90	90	90[a]
0.29	80	90	90	90	90	90
0.30	80	90	90	90	90[a]	90
0.31	80	90	90	90	90[a]	90
0.32	80	90	90	90	90	90[a]
0.33	70	90	90	90	90[a]	90
0.34	70	80	90	90	90[a]	90[a]
0.35+	60	80	90	90	90[a]	90[a]

* Conviction count does not include reference conviction.
[a] Extrapolated values.
[b] Below the 10th percentile.

Table 18

Combinations of BAC Level and Number of Prior 2-Year Total Convictions Leading to Relative Recidivism Rates Equal to or Higher Than Each Tenth Percentile Predicted by BAC, BAC^2, BAC^3, and Prior 2-Year Total Convictions: For Repeat Offenders

	Prior 2-year total convictions*					
BAC	0	1	2	3	4	5+
0.00	60	80	90	90	90	90
0.01	40	70	80	90	90	90[a]
0.02	30	50	70[a]	80	90	90[a]
0.03	20	40	60	80	90[a]	90
0.04	10[a]	30	50	70	80[a]	90[a]
0.05	0[b]	20	40	60	80	90
0.06	0[b]	10	40	50	80	90
0.07	0[b]	10	30	50	70	80
0.08	0[b]	10	30	50	70	80
0.09	0[b]	0[b]	30	50	70	80
0.10	0[b]	10	30	50	70	80
0.11	0[b]	10	30	50	70	80
0.12	0[b]	10	30	50	70	90
0.13	0[b]	20	40	50	80	90
0.14	0[b]	20	40	60	80	90
0.15	0[b]	20	50	70	80	90
0.16	10	30	50	70	80	90
0.17	20	40	60	80	90	90
0.18	20	40	70	80	90	90
0.19	30	50	70	80	90	90
0.20	40	60	80	90	90	90
0.21	40	60	80	90	90	90
0.22	50	70	80	90	90	90
0.23	50	70	90	90	90	90
0.24	60	80	90	90	90	90
0.25	70	80	90	90	90	90
0.26	70	80	90	90	90	90
0.27	70	80	90	90	90	90
0.28	70	80	90	90	90	90
0.29	70	90	90	90	90	90
0.30	70	80	90	90	90	90
0.31	70	80	90	90	90[a]	90
0.32	70	80	90	90	90	90
0.33	60	80	90	90	90	90
0.34	50	70	80	90	90	90[a]
0.35+	40	60	80	90	90	90

* Conviction count does not include reference conviction.

[a] Extrapolated value.

[b] Below the 10th percentile.

An example from Table 18 for repeat offenders would be a convictee with a BAC of 0.12% with one prior 2-year total conviction. This individual would be above the 10th percentile (i.e., in the 10th to 19th percentile) to recidivate. Another individual with the same number of prior 2-year total convictions, but with a BAC of 0.23%, would be above the 70th percentile (i.e., in the 70th to 79th percentile) to recidivate.

What is most important is that when the BAC level and the number of total convictions in the preceding two years are known, these tables can be used to estimate the probability that first or repeat offenders will recidivate, relative to other offenders, during the year after arrest. The information obtained can be used in evaluating the risk, absolute and relative, that individual DUI convictees pose to themselves and others.

The results shown in Tables 17 and 18 are displayed graphically in Figures 9 and 10. For both first and repeat offenders, the relationship between BAC and 2-year total convictions is clear. The decrease in recidivism at BAC levels of about 0.09% becomes less as the number of prior 2-year total convictions increases. For first offenders there is no decrease at all when there are five or more prior 2-year total convictions.

The greater the number of prior 2-year total convictions, the less different the recidivism rate is among different BAC levels. In general, these tables show that the number of prior convictions is a stronger risk factor than is BAC level. Any operational recidivism prediction model should include total prior convictions as a factor.

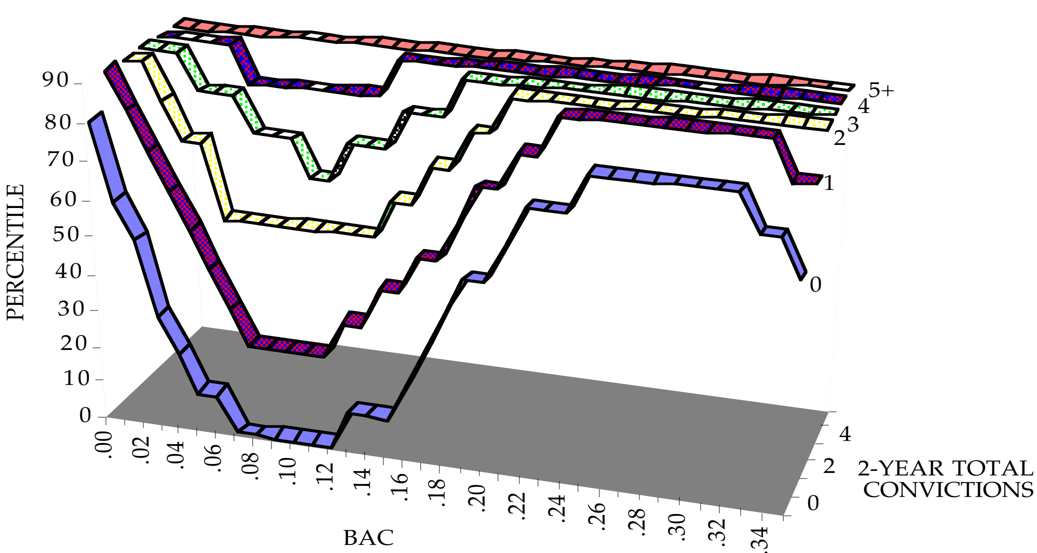


Figure 9. Decile rates of recidivism predicted by BAC, BAC^2, BAC^3, and 2-year total convictions: First offenders.

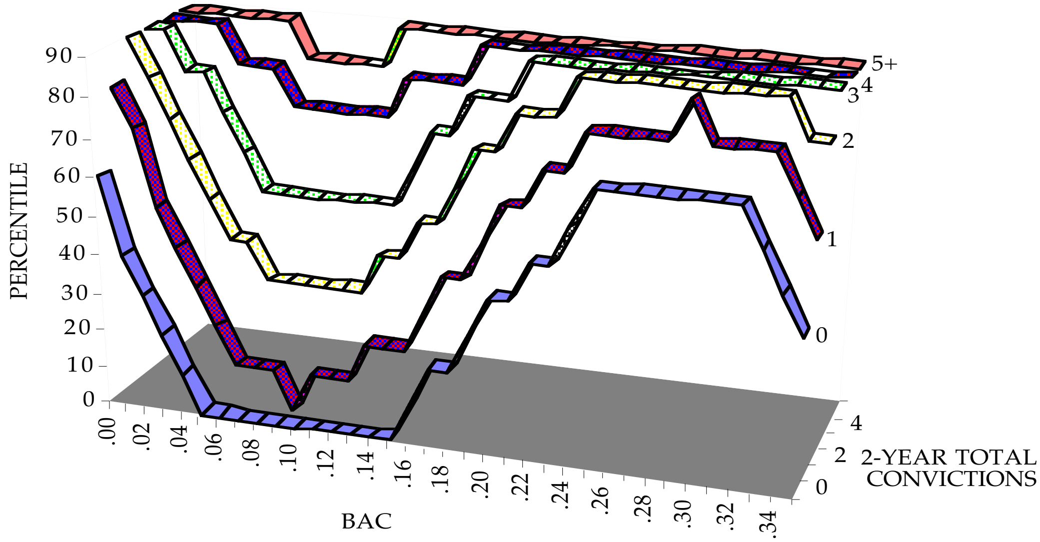


Figure 10. Decile rates of recidivism predicted by BAC, BAC^2, BAC^3, and 2-year total convictions: Repeat offenders.

Recidivism and BAC at Arrest

All analyses performed in this study showed that the probability of recidivism for DUI convictees during the year after arrest is related to the BAC level at arrest. The inclusion of BAC as a third degree polynomial resulted in equations with the flexibility to model the nonlinear relationship between BAC and recidivism. The pattern of this relationship is clearly shown in the graphical representations of the orthogonal polynomial regression and simple logistic regression models (see Figures 3 and 5-8). Contrary to expectations at the beginning of these analyses, however, the rate of recidivism was not a monotonic function of BAC level.

All models predict recidivism to be relatively high at 0.00% BAC. The logistic regression models predict recidivism to decrease to its lowest level at about 0.09% BAC (0.10% for the orthogonal regression), to increase to its highest level at about 0.29% BAC (0.31% for the orthogonal regression) and then to decrease slightly as BAC increases up to the pooled 0.35% plus group. The absolute and relative predicted rates of recidivism for different models at selected BAC levels are shown in Table 19.

Table 19 reveals that convictees with 0.00% BAC are predicted by the simple two factor logistic regression model to recidivate at a slightly higher rate than the positive BAC level with the highest predicted rate of recidivism. In fact, BACs of 0.00% and 0.29% appear to be local maximums for recidivism and each may reflect phenomena modulating subsequent impaired driving.

Table 19

Logistic Regression[a] Predicted Rates of Recidivism at Key BAC Levels: BAC, BAC^2, BAC^3, and Offender Level Model (Simple Two Factor Model)

BAC level	First offenders	Repeat offenders
0.00%	0.1086(1.94)[b]	0.1416(1.91)
0.10% (at lowest rate of recidivism)	0.0559(1.00)	0.0742(1.00)
0.29% (at highest rate of recidivism positive BAC levels)	0.1020(1.82)	0.1333(1.80)
0.35% plus	0.0788(1.41)	0.1038(1.40)

[a] Orthogonal regression and the simple three factor model produced similar results.
[b] Relative rates are in parentheses and are relative to the lowest rate predicted by the model.

All DUI convictees, even those with BAC levels showing the lowest rates of recidivism, had rates much higher than the DUI rate of the general driving population. During 1993 the overall DUI rate for California drivers was 0.0089. Table 20 shows how much greater the probability of a subsequent DUI was for DUI convictees in the sample relative to the average driver.

Table 20

Relative Logistic Regression (Simple Two Factor Model) Predicted Rates of Recidivism at Key BAC Levels for DUI Convictees Compared to the DUI Rate for the General Driving Population

Key level	First offenders	Repeat offenders
BAC = 0.00%	12.23	15.95
BAC = 0.10% (at lowest rate of recidivism)	6.29	8.36
BAC = 0.29% (at highest rate of recidivism for positive BAC levels)	11.48	15.01
BAC = 0.35% plus	8.87	11.69
Overall mean	7.65[a]	10.69[b]

[a] Mean probability of first offenders recidivating was 0.0679.
[b] Mean probability of repeat offenders recidivating was 0.0950.

Table 20 shows that DUI convictees who agree to have their BAC-tested are six to 16 times more likely to have a DUI in the next year than is the average California driver. The average BAC-tested DUI convictee had a 0.0769 predicted probability of recidivating[5], which was 8.66 times as great as the rate of DUI convictions for the general driving population.

The complex logistic regression model using only main effect factors showed that DUI convictees who refused BAC testing had a 22.7% greater probability of recidivating than

[5] For logistic regression, simple model based on BAC and offender level (first or repeat offense).

the average BAC-tested convictee. Therefore, the average BAC test-refusing DUI convictee had 10.63 (8.66 x 1.227) times the probability of a subsequent DUI as the general driving population.

The relative probabilities of recidivism for BAC-tested first (7.65) and repeat offenders (10.69), and for BAC test refusers (10.63), are consistent with the finding in the complex models that the rate of recidivism of BAC test refusers was significantly greater than for BAC-tested first offenders, but not significantly different than BAC-tested repeat offenders. Consequently, the percentile of recidivism for BAC test refusers could be based on the mean BAC for repeat offenders, which is 0.173%. Table 18 shows that for a BAC of 0.17%, the rate of recidivism for BAC-tested repeat offenders would vary from the 20th percentile to 90th percentile, depending on the number of prior 2-year total convictions.

Choice of Initial Model Affects Final Model

Two complex logistic regression models were used. One started with 14 main effect factors and ended with a final model containing 10 significant factors. The other consisted of the same 10 main effect factors that were significant in the first model and 28 2-way interaction factors[6]. The main effects plus interaction model had a final form consisting of all 10 main effect factors plus four 2-way interaction factors. These models, as expected, gave slightly different predicted probabilities of recidivism within one year for hypothetical individuals. The factor values for four hypothetical individuals and the predictions of recidivism made for them by the models are presented in Table 21.

Table 21

Predicted Probabilities of Recidivism Within One Year for
Four Hypothetical DUI Convictees: Complex Models

Factor	Convictee #1	Convictee #2	Convictee #3	Convictee #4
BAC	0.15	0.12	0.23	0.08
Reference event an accident	no	no	no	yes
2-year total convictions	3	1	2	1
2-year HBD accidents	1	0	1	1
2-year DUI convictions	2	1	2	1
Offender level	repeat	first	repeat	first
Age	25	50	35	40
Gender	M	F	M	M
BAC x offender level[a]	0.15	0	0.23	0
BAC x 2-yr HBD accidents[a]	0.15	0	0.23	0.08
2-year DUI convictions x offender level[a]	2	0	2	0
Age x offender level[a]	25	0	35	0
Main effects model prediction[b]	0.1265	0.0299	0.1601	0.0343
Main effects + 2-way interaction model prediction[c]	0.1342	0.0254	0.1353	0.0407

[a] Factor only in main effects + 2-way interaction model.
[b] Model parameters are shown in Table 4.
[c] Model parameters are shown in Table 7.

[6] BAC^2 and BAC^3 were not embedded in 2-way interactions, and a sequential analysis was performed.

Two simple logistic regression models were used. One consisted of BAC, BAC^2, BAC^3, and offender level (simple two factor model) and the other consisted of the same factors plus prior 2-year total convictions (simple three factor model). Like the complex models, these simple models predicted slightly different probabilities of recidivism for hypothetical individuals. The four hypothetical individuals used as examples were the same as for the complex models, but only the factors contained in the simple models were used in the computation of recidivism risk. The factor values and predictions of recidivism made by these models are shown in Table 22.

Table 22

Predicted Probabilities of Recidivism Within One Year for
Four Hypothetical DUI Convictees: Simple Models

Factor	Convictee #1	Convictee #2	Convictee #3	Convictee #4
BAC	0.15	0.12	0.23	0.08
Offender level	repeat	first	repeat	first
2-year total convictions[a]	3	1	2	1
BAC & offender level model	0.0831	0.0572	0.1184	0.0569
BAC, offender level, & 2-year total conviction model	0.0897	0.0456	0.1141	0.0441

[a] Factor only in BAC, BAC^2, BAC^3, offender level, and prior 2-year total conviction model.

Although the choice of initial model can be shown to slightly alter the recidivism predictions in individual hypothetical cases, the overall concurrence between prediction models is quite high. The model which includes prior 2-year total convictions as a factor is the more accurate of the two simple models because this factor explains variance in post 1-year DUI recidivism in addition to that explained by BAC alone. As a result, the number of prior 2-year total convictions modifies the prediction of DUI recidivism among convictees with the same BAC level, making it more accurate.

Correlation Between Conviction BAC Level and Other Arrest BAC Level

For subjects who recidivated, BAC levels at recidivism were compared with BAC levels associated with the reference conviction. In some cases where BAC at recidivism was not available, BAC at a subsequent or prior arrest was used. Most of these subsequent or prior arrests occurred within 12 months of the arrest associated with conviction, but a few occurred up to 15 months before or after it.

BAC levels at recidivism could be found for 2,724 (75.3%) of the 3,618 subjects who recidivated. The mean and distribution of conviction BAC levels for the subjects used in this analysis were similar to those of the entire recidivism sample. The correlations of BAC levels, which were all significant ($p<0.0001$), were 0.523 for first offenders, 0.540 for repeat offenders and 0.533 for all offenders.

The distributions of BAC levels were similar for reference convictions and other arrests, with at least 5% of sample subjects found at each BAC level from 0.11% to 0.20% for the reference conviction and from 0.12% to 0.21% for the other arrest. While the correlations obtained were moderately high, they indicate a substantial amount of variation in the BAC values of convicted offenders across different arrest incidents. This is possibly due to the restricted and truncated range of BAC levels used, relative to the overall range. This type of distribution, which has a relatively small variance, tends to deflate correlations. In addition, arrests occur at varying intervals after the last consumption of alcohol and BAC level changes as alcohol is metabolized by the body. Thus, in the absence of a measurement of BAC at a specified time after the last drink, the measured BAC level contains additional error, which would also lower the correlation obtained in this analysis.

Despite the deflated correlation values obtained, this analysis does indicate that BAC levels at arrest on two occasions occurring within 15 months tend to be similar. Thus, a motorist arrested for DUI with a high BAC level will more likely have a high BAC level at the next arrest. Regardless of whether the BAC level is low, moderate, or high, the BAC level at an arrest is very suggestive of the BAC level that will be found if the motorist recidivates. It also substantiates the chronicity of problem drinking among drivers with two or more DUI offenses.

An additional analysis divided offenders into 5 groups based on the conviction BAC in order to determine if the correlation with BAC at the other arrest varied among the groups. The results are shown in Table 23.

Table 23

Correlation Between Conviction BAC and BAC at Other Arrest

BAC range of groups	Correlation between conviction BAC and other arrest BAC
0.00%-0.06%*	0.350
0.07%-0.13%	0.076
0.14%-0.20%	0.175
0.21%-0.27%	0.205
0.28%-0.35%+	0.256

*$p = 0.06$. For all other correlations, $p<0.05$.

The correlations obtained in this analysis were, as expected, smaller than the correlation obtained for all subjects because each group contained only part of the overall sample and the range of conviction BAC levels was severely limited. The analysis shows that the correlation between BAC at conviction and other arrest was greater at lower and higher conviction BAC levels than at intermediate levels. This indicates that convictees with both low and high BAC levels tend to have more similar BACs from arrest to arrest than do convictees with intermediate BAC levels. It also suggests that the use of drugs (found with increasing frequency as BAC level decreases) has some consistency in that those convicted with low BAC levels tend to also have low BAC levels when rearrested.

Predictions of Recidivism Based on Models Developed and Independent Variables Used

The AIC is used when comparing different models for the same data. The value of AIC of the model containing only the intercept (A_I) and the value of AIC of the model containing the intercept and variables (A_{I+V}) may be combined to form a statistic which compares fitted values under these models. The resulting value is a proportion measuring how much better the intercept plus variables model fits the data than does the intercept only model. The equation, which results in a relative AIC (AIC_{rel}) is:

$$AIC_{rel} = (A_I - A_{I+V}) \; / \; A_I$$

Values obtained for the various models are shown in Table 24.

Table 24

Relative AIC of Logistic Regression Models: Relative to the Intercept-Only Model

Comparison being made	Model	Relative AIC
BAC containing records	Complex: main effects + 2-way	0.026
"	Complex: main effects	0.024
"	Simple: three factors	0.018
"	Simple: two factors	0.009
BAC vs. refusal records	Complex: main effects + 2-way	0.019
"	Complex: main effects	0.020
Refusal records	Complex: main effects + 2-way	0.006
"	Complex: main effects	0.008

All relative AIC values are small indicating that each model involving independent variables results in only a small improvement over the intercept-only model. This finding suggests that the combination of variables in the models accounts for only a minor part of the recidivism that will occur, and that other unidentified factors and chance account for a large part of the outcome variance. Thus, the predictions of these models should be only one factor in determining appropriate sanctions and treatment for DUI convictees. Additionally, these results underscore the constraints imposed by the brief driving record interval.

The simple three factor model (Table 12) predicts that repeat offenders are 25.3% more likely to recidivate than first offenders with the same BAC level and number of prior 2-year total convictions. For convictees with the same number of prior 2-year total convictions, first offenders with very high BAC levels have higher probabilities of recidivating than do repeat offenders with relatively modest BAC levels. Some examples of this are shown in Table 25, which is based on data shown in Tables 13 and 14.

Table 25

Examples of Similar Rates of Recidivism Predicted by the Simple Three Factor Model for First and Repeat Offenders

Number of 2-year total convictions	First offender		Repeat offender	
	BAC	Predicted recidivism rate	BAC	Predicted recidivism rate
1	0.16%	0.0539	0.09%	0.0542
1	0.29%	0.0917	0.22%	0.0921
2	0.18%	0.0717	0.14%	0.0723
2	0.30%	0.1077	0.22%	0.1091
3	0.33%	0.1150	0.19%	0.1102
4	0.17%	0.1133	0.12%	0.1126
5	0.22%	0.1715	0.18%	0.1700

Another way to show how first offenders at specified BAC levels and repeat offenders at other BAC levels have the same predicted rate of recidivism is presented in Figure 11.

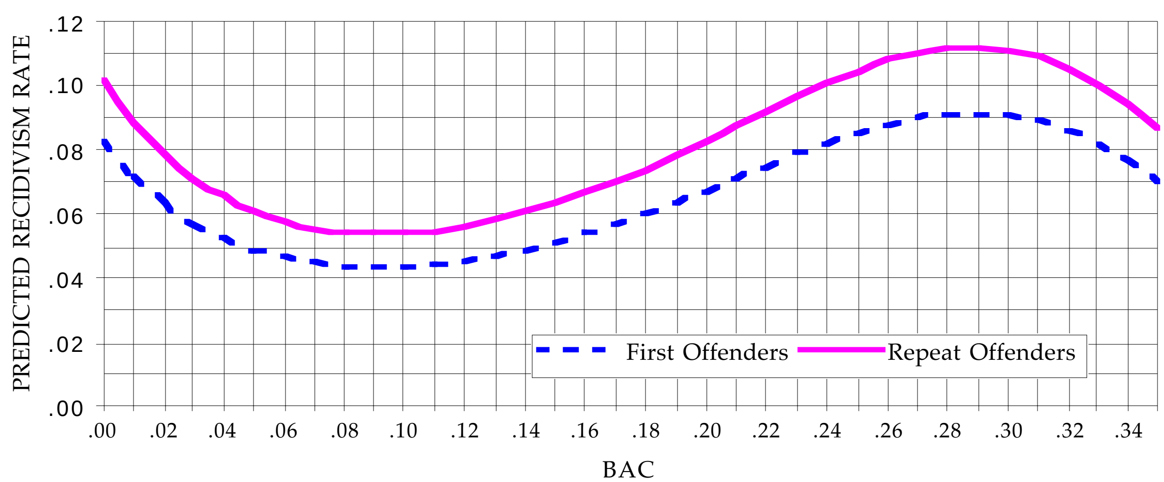


Figure 11. Predicted recidivism rate for first and repeat offenders with one prior 2-year total conviction

Figure 11 shows recidivism rates for DUI convictees with one prior 2-year total conviction. The graphs show a complex relationship between recidivism rate and the BAC levels of first and repeat offenders, but some general rules are evident. First, the highest recidivism rates for repeat offenders and the lowest recidivism rates for first offenders have no comparable values in the other offender group. Second, the recidivism rates for first offenders are often the same as for repeat offenders at legal BAC levels when their BAC levels are lower, and at illegal (except the highest) BAC levels when their BAC levels are higher. The differences in BAC levels for comparable recidivism rates between offender groups ranges from about 0.02% to about 0.07%.

Recidivism rates for DUI convictees with more than one prior 2-year total conviction show comparable, although not identical, general relationships. The overall patterns of the relationships are similar.

Receiver Operating Characteristic (ROC) Curves

Receiver operating characteristic curves were developed in the context of signal detection theory to evaluate the association between the presence and absence of a signal and a detector's ability to discriminate between both possibilities. For logistic regression, a parallel is the ability of a model to correctly predict the occurrence or nonoccurrence of an event. In other words, how closely do predicted outcomes match observed outcomes.

An ROC curve presents the performance of a model across all cutoff thresholds and signal intensities. Examination of the ROC curve enables the outcome of the model (value of the logistic regression equation) to be determined which maximizes both detecting the presence and absence of an event (correctly predicting that an event will or will not occur).

ROC curves are drawn along with a 45° diagonal reference line. An ROC curve which is coincident with the 45° diagonal line indicates that the detection device or model is unable to distinguish signals from noise. The more that the ROC curve diverges from the diagonal by bowing to the upper left, the better the performance of the detector or, in the current instance, the prediction model.

The abscissa for ROC curves is 1-specificity. Since specificity is the ability to correctly detect the absence of a signal, 1-specificity is incorrectly judging a signal to be present or the false alarm rate. The ordinate for ROC curves is sensitivity. Sensitivity is the ability to correctly detect the presence of a signal or the hit rate. The portion of the ROC curve closest to the upper left of the chart indicates the detection threshold value (for this analysis, the model equation value) which results in the optimum combination of hit rate and false alarm rate. The threshold value must have a high hit rate, but not so high that the false alarm rate gets too great.

ROC curves obtained from logistic regression analyses in this study show that all models are able only to modestly discriminate DUI recidivators from nonrecidivators. The complex models resulted in the curve diverging a greater amount from the diagonal than the simple models, which indicates better discrimination of signal from noise (i.e., recidivators from nonrecidivators) by the complex models. These findings are consistent with the relatively low rate of recidivism observed (7.7%) during the first year after arrest, with the low to moderate rate of recidivism found in each cell, and with the greater differentiation and compartmentalization of subjects by the complex models.

ROC curves are shown for all models in Figure 12.

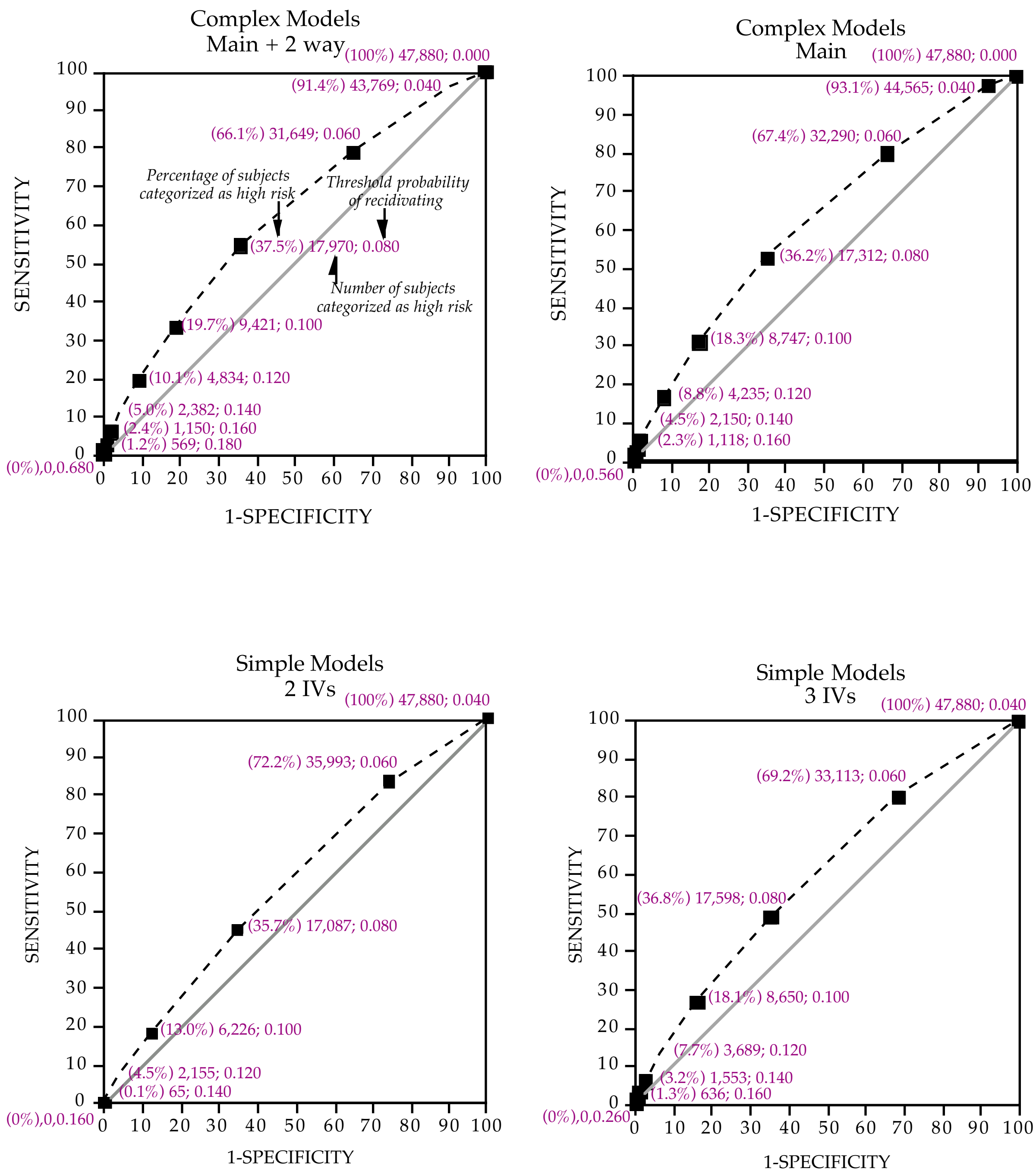


Figure 12. ROC curves for complex and simple logistic regression models.

For each curve, the threshold probability of recidivating, and the number and proportion of subjects that is above each threshold, are shown. The receiver operator curves indicate that the models have optimum sensitivity for discriminating between recidivists and nonrecidivists when the threshold probability for recidivism is slightly less than 0.080. That is the part of each curve which is closest to the upper left corner of the unit square. At this point, the hit rate is high while the false alarm rate is low. For this threshold, about 40% of all BAC-tested DUI convictees would be classified as having a high risk to recidivate.

The findings of the ROC curves can be restated in applied terms. Whenever a predicted probability of recidivism of DUI convictees of about 0.080 or greater is obtained from the model equation, then those convictees would be placed in the high risk group. This will put about 40% of DUI convictees in the high risk group, and will have a relatively high hit rate. Applying this criterion to the hypothetical DUI convictees modeled in Table 21 and 22, convictees 1 and 3 from each table would be categorized as being at high risk to recidivate. Their predicted probabilities of recidivating would be analogous to signals and the detector of high recidivism risk would be the threshold criterion of 0.080.

The above threshold criterion, like any other, has associated with it false positive and negative rates. This is illustrated in Table 26.

Table 26

Rates of True and False Positives and Negatives for a Threshold to Recidivate Criterion of 0.080. Complex Main Effect and Interaction Model

Observed	Predicted DUI recidivism		
DUI recidivism	Yes	No	Row total
Yes	true positive 2,001 (11.1%)	false negative 1,680 (5.6%)	3,681
No	false positive 15,969 (88.9%)	true negative 28,230 (94.4%)	44,199
Column total	17,970	29,910	47,880

phi coefficient = -0.06

Table 26 shows that 11.1% of the 17,970 subjects predicted to recidivate at a threshold criterion of 0.08 actually did recidivate. Conversely, 5.6% of the 29,910 subjects predicted not to recidivate at this threshold criterion actually did recidivate. This analysis shows that almost 95% of those who are predicted not to recidivate do not recidivate, but only about 11% of those who are predicted to recidivate do so. Fifty-four percent of recidivators (2,001/(2,001 + 1,680)) and 63.9% of nonrecidivators (28,230/(15,969 + 28,230)) are correctly identified.

The area under each ROC curve is equal to the probability of correctly distinguishing recidivists from nonrecidivists. This statistic has a range of 0.5, when the model has zero discriminability and there is a 50% chance of assignment to the correct group, to 1.0, when the model has perfect predictability and there is a 100% chance of assignment to the correct group. Its estimates of statistical significance are equivalent to the Wilcoxon rank order statistic, W (Hanley & McNeil, 1982). Both statistics measure the probability of a correct ranking (placement in nominal groups) of pairs of events (recidivism, nonrecidivism).

The probability of each model predicting group membership, based on the value of *c* which is output by SAS PROC LOGISTIC as a measure of *W*, is shown in Table 27.

Table 27

Probability of Predicting Correct Outcome

Model	Probability
Complex model: main effects + 2-way interactions	0.627
Complex model: main effects	0.625
Simple model: three factors	0.605
Simple model: two factors	0.579

As stated previously, these probabilities show that for the one year following arrest, recidivism can be only modestly predicted. There is little difference in predictive ability between the simple model using three factors and the most complex model using main effects and 2-way interactions. This suggests that the use of the former in applied settings would give results very similar to those obtained from the use of the latter.

One limitation of using a cutoff criterion which maximizes relative sensitivity is that it does not consider the absolute number of false positives and true negatives generated by the decision rule. Another model that has been proposed is to select a cutoff which equalizes the marginal distribution, thereby producing equal numbers of false positive and false negative errors. This decision rule, which also has the property of maximizing the correlation (phi coefficient) between the predicted and observed outcomes, produced higher cutoff thresholds than did the prior criterion. This is shown in Table 28, which is the 2 x 2 table of predictions versus observations that results in the optimum prediction value for the complex main effects and 2-way interactions model.

Table 28

Optimum Prediction 2 x 2 Table of Predictions and Observations
for Complex Main Effects and 2-Way Interaction Model

Observed	Predicted: Recidivist	Predicted: Non recidivist	Row total
Recidivist	568 (15.4%)	3,113 (7.0%)	3,681
Non recidivist	3,113 (84.6%)	41,086 (93.0%)	44,199
Column total	3,681	44,199	47,880

phi coefficient = -0.08

The optimum prediction values for all models are shown in Table 29.

Table 29

Optimum Prediction Value

Model	Value
Complex model: main effects + 2-way interactions	0.129
Complex model: main effects	0.125
Simple model: three factors	0.120
Simple model: two factors	0.112

As implied above, the most effective prediction threshold obtained from the receiver operator curves is the probability of recidivism which maximizes sensitivity and specificity, thereby resulting in equal numbers of false negative and false positive predictions. All subjects with prediction values above the threshold would be included in the high risk to recidivate group. It is important to understand that this criterion assumes that false positive and false negative errors have equal importance. Where one type of decision error has greater importance relative to disutility than the other, a different cut-off threshold can produce more optimal results.

Simpson's Paradox

Borkenstein, Crowther, Shumate, Ziel, and Zylman (1964) studied the relationship between BAC level and fatal traffic accidents. They found a decrease in fatal accident rate at low BAC levels which has since been shown to be an artifact of small sample sizes at the low BAC levels (despite a large overall sample size, as well as disproportionate representation of demographic subgroups at different BAC levels) (Hurst, Harte, & Frith, 1994). In spite of the dip in accident rate observed in the collapsed data at low BAC levels, all of the subgroups exhibited accident rates that increased montonically with BAC level. This phenomenon is known as Simpson's paradox (Simpson, 1951), and has been described in detail elsewhere (Mittal, 1991; Samuels, 1993).

Since sample sizes in this study are relatively small at low BAC levels, the results were analyzed to determine if Simpson's paradox holds for and negates the findings obtained. If demographic subgroups are not homogeneously represented in this study, then the observed patterns of recidivism should be different for these subgroups.

In order to determine if subgroups of subjects exhibited BAC-related patterns of recidivism that differed from the patterns seen for the overall collapsed data, the relationship between recidivism and BAC was graphed for some subgroups and for the collapsed data. Three subgroups by age (up to 29 years, 30-49, 50 and up) were chosen because they each had enough subjects to calculate recidivism rates at most BAC levels. Finer subgrouping by age could not be used because many BAC levels in these subgroupings had no subjects. Subgroups by gender were also compared. The results of the graphing comparison are shown in Figure 13.

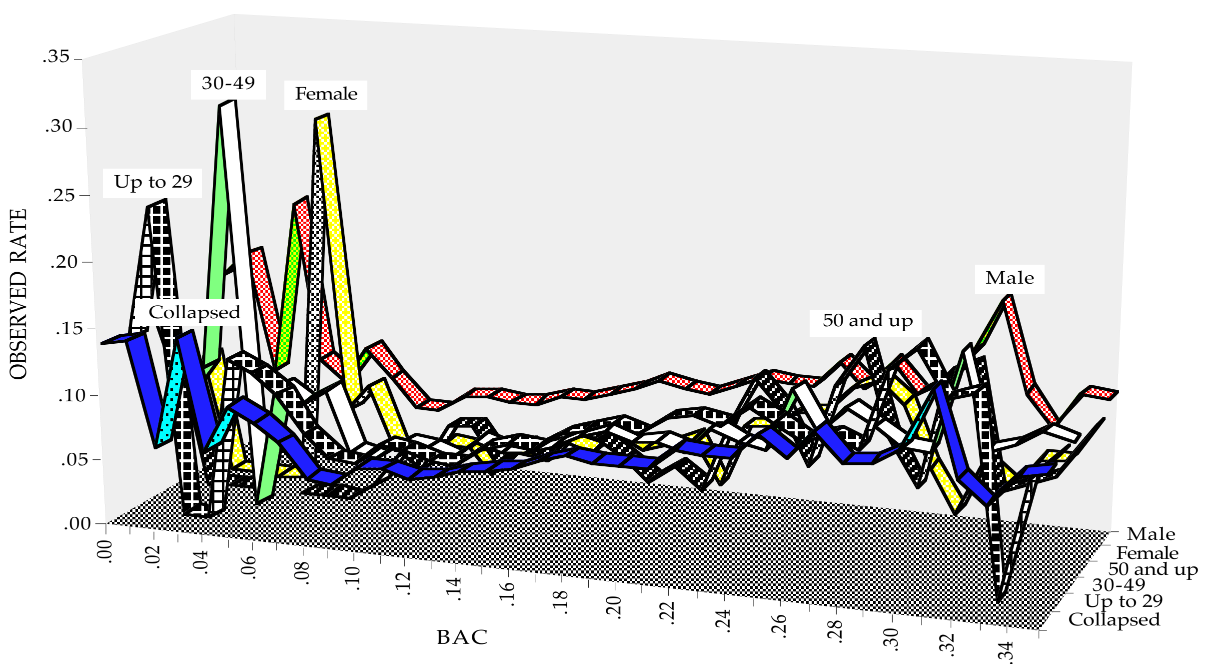


Figure 13. Observed rate of recidivism for collapsed data, age, and gender subgroups

Although the patterns of observed recidivism are complex for the collapsed data and for each of the subgroups, all show similar patterns of high rates of recidivism at low BAC levels, minimum rates at BACs of about 0.09%, increases in rates up to BACs of about 0.30% followed by a fall-off in rates as BAC increases to the highest levels included in the graph. These findings argue against non-homogeneity of subgroups and against the presence of the subgroup reversal phenomenon known as Simpson's paradox.

DISCUSSION AND CONCLUSIONS

The Relationship Between BAC at Arrest and Recidivism

The BAC level of drivers convicted of DUI is statistically related to the probability of DUI recidivism during the year following arrest. Every predictive model, complex and simple, used in this study of convictees with BAC levels on their driver records shows BAC level to be a significant predictor of recidivism. A third degree polynomial or cubic relationship between BAC level and recidivism was shown in all models. The form of this relationship showed recidivism to be high at a BAC of 0.00%, decreasing to a BAC of 0.09%, increasing to a BAC of about 0.29%, and then decreasing to a BAC of 0.35% plus (the highest BAC level grouping in the study). This relationship held for both first and repeat offenders.

Due to annual purging of DMV driver record entries, the pre-arrest and post-arrest time periods for which minor violations and accidents on driver records could be obtained were limited. The 2-year pre-arrest period used in this study for counting prior driving convictions and accidents is shorter than the 3-year period that is available for review when arrests actually occur. The longer time period contains more driving history, thereby enabling a model to better differentiate among convictees based on prior driving record. As a result, the models developed here understate the potential predictive utility of prior driving record information.

Similarly, a longer post-arrest tracking period of three to five years, instead of the one year period available to this study, would allow recidivism to be monitored for a longer time. Data from a longer time period would be expected to show relationships between prior driving history, BAC, and other factors, such as age and subsequent driving record, that would be stronger than those shown in this study. This would be expected because those with a propensity to drink and drive would have more opportunity to do so and to be arrested during a longer post-arrest time period. That is, continued driving while intoxicated would be more likely to be identified over the longer time period, and, consequently, the number of DUI convictees who recidivate would be greater. This is underscored by Tashima and Marelich (1989), who showed that BAC level for first and second DUI offenders had adjusted R^2 values for alcohol-related criterion measures of between 1.6 and 5.1 times greater for 2-year post-arrest periods than for 1-year periods.

The BAC level of convictees predicts recidivism both as a result of it being high and very low or zero. In the former case, alcohol dependency is likely, while in the latter, use of other impairing substances is suggested. The presence of a moderate (among DUI convictees) BAC level of about 0.09% predicts a much lower rate of recidivism than either extreme, which may mean that individuals impaired at such intermediate levels are less frequent drinkers who have not developed the tolerance to alcohol of heavy drinkers. The driving of less frequent drinkers would be expected to be impaired at more moderate BAC levels than for heavy drinkers. For some moderate BAC level convictees, alcohol may be more of a discretionary substance than an addiction. The converse would be expected for the high BAC level convictees. While it is beyond our current knowledge to fully understand what the BAC levels of DUI convictees reveal about them, very high BAC levels are very likely symptomatic of problem drinking and alcohol dependency.

A BAC of 0.00% found in drivers convicted of DUI is a likely indication of the presence and influence of drugs other than alcohol. The presence of drugs in approximately 90% of 1993 DUI arrestees with 0.00% BAC in 46 California counties[7] (Phillips, 1995) supports this contention. Thus, DUI convictees with 0.00% BAC levels appear overwhelmingly to be drug users whose recidivism expectancy within one year is similar to that of DUI convictees with BACs of 0.29% at arrest.

A BAC level of 0.29%, the positive BAC level with the highest rate of recidivism, is a level at which only chronic alcohol-dependent drinkers could continue to function at tasks such as driving a motor vehicle. Extremely elevated BACs can be considered to be an indication of probable alcoholism and individuals with such BAC levels would be expected to be highly addicted to alcohol. The ongoing high consumption of alcohol by these individuals, along with their demonstrated inability to separate driving from drinking, leads to a relatively high probability of recidivating within one year.

These two causes of impairment, drugs and alcohol, appear to be related to DUI recidivism with the maximum manifestations of each occurring at widely divergent BAC levels. These levels, 0.00% and 0.29%, may reflect the relatively pure effect of drugs and alcohol, respectively, on recidivism. However, since users of intoxicating substances commonly use more than one such substance at a time, many DUI convictions reflect the use of both alcohol and other drugs.

As BAC increases or decreases from 0.29%, the likelihood of recidivism during the next year gradually decreases. This may reflect decreased driving because of alcohol-related illness, greater ability to separate drinking and driving, the impact of sanctions, or other factors. Higher rates of recidivism by drivers with high BAC levels may reflect the heavy drinking of these individuals and their driving at BAC levels that result in driving behavior which is detectable by police observation. Drivers with the highest BAC levels are likely to receive more stringent sanctions, which may lower their driving exposure and, therefore, their probability of recidivating. In general, when measuring the rate of recidivism during the year after arrest, most convictees would have received driver license actions which would have lessened their driving exposure. Thus, observed rates of recidivism must be viewed in the context of these real-world limitations and influences.

<u>Predictions of Recidivism Based on Models Developed and Independent Variables Used</u>

The probability of recidivism predicted by the BAC, BAC^2, BAC^3, prior 2-year total convictions, and offender level model for combinations of prior 2-year total convictions and BAC level (shown in Tables 13 and 14 for first and repeat offenders, respectively) could be used by presentence investigators or judges to determine appropriate sanctions. These data may have potential application in administrative settings as well. For example, a potential pilot program of early license reinstatement for offenders

[7] Six types of drugs were tested for: Opiates, Methamphetamine, Benzodiazepines, Cocaine, Phencyclidine, and Marijuana. Intoxication in the remaining 10% may have been caused by drugs other than those tested for or by an undiagnosed medical condition, or may have been misperceived by the arresting officer.

agreeing to have ignition interlock devices installed on their vehicles might use these data to determine eligibility based on estimated recidivism risk. Tables 17 and 18 can be used if the relative probability of recidivism among DUI convictees, rather than the actual probability value, is deemed to be more helpful in distinguishing DUI convictees as being of higher risk to recidivate.

The findings presented in these tables provide support for applying the same sanctions and treatment requirements to first offenders with relatively high DUI recidivism probabilities as to repeat offenders with relatively modest DUI recidivism probabilities. It may not be necessary to wait until drivers have been convicted of more than one DUI before considering them to be at high risk to recidivate. Another potential advantage of initiating substance abuse treatment for high risk first offenders is that earlier treatment might be more effective than delaying treatment to the point of the second offense. Finally, more intensive treatment at the first offender stage can potentially prevent or delay the commission of a second DUI offense.

The similarity between first offenders with a high risk to recidivate and repeat offenders would be expected to be more pronounced in a study with a longer follow-up period. The only major difference between high risk first offenders and repeat offenders may be that the former have, through chance, only been caught offending once. Although the accuracy of the BAC-recidivism relationship in predicting a first offender's recidivism status is not yet sufficient to support a blanket policy, there is reason to believe, as noted above, that the use of a longer follow-up period would substantially increase the magnitude of the predictive relationship, particularly if prior total conviction frequency is considered along with the BAC level of the first offender.

As the findings of this study show, several prior 2-year total convictions can increase predicted recidivism as much as a large increase in BAC level. In fact, Tables 13, 14, 17 and 18, as well as Figures 7 and 8, show that prior 2-year total convictions is the more potent predictive variable, especially at intermediate BAC levels. That is, the recidivism rate does not change as much by BAC level as it does by the number of prior 2-year total convictions at a given BAC level. The relative strength of prior 2-year total convictions as a predictor of DUI recidivism is also substantiated by the size of its partial regression weights in the logistic regression equations which consistently yielded the largest Wald chi-square values.

A study (Marowitz, in press) performed since the completion of this report analyzed the prediction of DUI recidivism using factors other than those obtained from driver records. In the first part of this study, based on data from the El Cajon, California municipal court, two alcohol assessment instruments, the Michigan Alcohol Screening Test (MAST) and the CAGE[8] test, as well as an assessment of the level of alcohol dependency by trained interviewers, were used as predictive factors. Neither of the assessment instruments nor the interviewers' assessments of alcohol dependency were significant predictors of DUI recidivism. A final model was significant (p<.05) and contained prior 1-year total convictions, gender, and prior 1-year fatal & injury accidents (although prior 1-year fatal & injury accidents was not close to being significant).

[8] The CAGE acronym is derived from the first letter of a keyword from each of the test's four questions.

In the second part of the study, based on data from the San Diego County (CA) Alcohol and Drug Services which had been compiled from DUI treatment programs in the county, a wide variety of demographic factors were analyzed. A final model predicting DUI recidivism in the year after arrest was significant ($p<.05$). DUI recidivism was found to decrease with increasing years of education and age, and to increase with increasing number of prior alcohol or drug treatment experiences. DUI recidivism was greater for active duty military personnel, for males in general, and less for those employed full-time. In addition, the rate of recidivism increased with prior 7-year DUI convictions, prior 7-year DUI convictions squared, prior 1-year total convictions, and BAC level at arrest.

A conclusion from these two studies is that, in the presence of driver record factors, some nondriving factors, notably education, age, prior alcohol or drug treatment, active duty military service, full-time employment, and gender, are significant predictors of 1-year DUI recidivism for DUI treatment program attendees. Conversely, the MAST and CAGE tests, and alcohol dependency level based on interviews, are not significant predictors of DUI recidivism, even in the absence of driver record factors for DUI convictees assessed by the court.

Recidivism and Age at Arrest

Among BAC tested DUI convictees, recidivism decreased with age. This finding is probably related to the general propensity for risk taking and experimentation among youth, and their lower tolerance for alcohol. The decrease in DUI recidivism with age may also reflect the successful treatment or reduction of drinking problems as individuals age, as well as the deaths and illness of heavy drinkers at relatively young ages, with resulting decreases in driving exposure.

Utility of Simple Models as Predictors of Recidivism

Drivers convicted of DUI have varying probabilities of recidivism. This study examined near-term recidivism, that is, recidivism occurring within one year. In a 1977 paper, Simpson introduced the notion of at least two distinct types of DUI offenders: "the problem driver who drinks" and "the problem drinker who drives." Problem driving has been described as a type of anti-social and, at times, criminal behavior (Friedman et al., 1995). Arstein-Kerslake and Peck (1985) and Peck et al. (1994) developed a complex DUI offender typology containing both problem drinker and problem driver types.

Peck et al. (1994) concluded that the "two most important dimensions underlying drunk driving are the extent of aggressive unlawful driving (moving and nonmoving violations) and severity of the offender's drinking problem." They also found that criminal record, specifically arrests for malicious mischief and crimes of aggression, occurred more frequently among recidivists than among nonrecidivists. Recidivists were also more likely to have had higher BAC levels at arrest and serious alcohol problems, as judged by the intake counselor.

Simpson's original dichotomy might be better restated in light of these more recent findings. Problem drivers might better be seen as individuals who have broader problems than just those involving driving. These problems encompass anti-social or criminal behavior, and are manifest when the individuals are driving as well as when they are not. While the number of prior 2-year total convictions is probably related to the propensity for anti-social or criminal behavior, BAC level should be considered to be related to problem drinking or drug use. In predicting recidivism, each of these variables relates to a different underlying characteristic found in DUI convictees. Together, these variables measure the contributions of problem drinking and anti-social behavior to DUI recidivism. As might be expected, offenders who have high values on both dimensions represent the highest recidivism risk.

A model which provides quantitative insight into these behaviors would be extremely helpful to judges and administrative hearing officers who have to apply appropriate sanctions to DUI convictees. The predictions of such a model could be used along with other factors such as criminal record, prior sanctions and treatment history to guide sentencing decisions.

While the model using only BAC in conjunction with first or repeat offense status offers information about the alcohol problem of convictees, it does not provide much information about their overall propensity toward aggressive and high risk driving behavior. The model which adds prior 2-year total driving convictions contains information related to this factor. Any illegal BAC level can be associated with an increased probability of recidivating when prior 2-year total convictions are also considered. As BAC level increases, fewer total convictions are also required for an individual to be considered to have a high probability of recidivating.

Tables 17 and 18 can be used to compare each convictee to the predicted recidivism percentiles of first and repeat offenders, respectively. The percentile ranking of convictees would help in evaluating the risk for subsequent impaired driving that each will pose to the public. While there is no absolute standard below or above which convictees can be judged to be at regular or high risk to recidivate, the percentile scale does provide a relative standard. Using this scale, a convictee above the 90th percentile would be viewed very differently than one above the 10th percentile, and sanctions could be applied accordingly.

The relevance of using the percentile risk analysis as an aid in sentencing is apparent from Hedlund (1994) who stated that for fatally injured drivers in 1992, 41% had a positive BAC, 34% had a BAC of 0.10% or higher, and 16% had a BAC of 0.20% or higher. Among BAC tested DUI convictees in the present study, 91.5% had BACs of 0.10% or greater and 25.5% had BACs of 0.20% or greater. To the extent that a positive or high BAC confers an elevated risk of being fatally injured, these offenders are at a relatively high risk of becoming driving fatalities.

Additionally, DUI convictees with BAC levels below 0.08%, especially with 0.00% BAC, should be viewed in light of their relatively high rate of recidivism. Judges and administrative hearing officers in considering such cases should take into account that impairment was likely due, in part or in whole, to drugs other than alcohol, and may wish to investigate for possible drug abuse. Low BAC levels should not cause DUI convictees to be treated casually. Convictees with very low BAC levels should be considered to be serious offenders and should receive punitive and treatment sentences which will ensure that any drug-related problems present are identified and addressed.

One mechanism of utilizing the reoffense risk profiles developed in this study is through the presentence investigation process. CVC §23205 authorizes courts to utilize the presentence investigation process in DUI cases. An individual's level of risk, along with other factors, could be used to confer a high risk designation.

Although these results provide support for some form of customized or "predictive" sentencing based on actuarial risk profiles, the existing literature is not sufficient to permit specific direction to the structure of a more customized sanction system. Under current law and practice, very little customization takes place in the sense of varying the specific type and duration of punitive, educational, and alcohol remediation as a function of the individual characteristics of the offender and offense.

One relatively new sanction or control agent that is available to the courts is ignition interlock (CVC §23235). The use of ignition interlock, along with license suspension and alcohol treatment in Senate Bill 38[9] programs, for high risk offenders should be considered. Alternatively, ignition interlock could be used for high risk offenders as a condition of license reinstatement after the period of license suspension has ended. Sections 13352(a)(4),(6), and (7) of the California Vehicle Code authorize the department to conduct interviews prior to reinstatement of specified DUI recidivists.

<u>Further Research</u>

A future study should reanalyze these subjects using a 3- to 5-year follow-up period. A parallel study should use different subjects for whom three years of pre-arrest data, as well as a 3- to 5-year follow-up period, are available. Both of these studies would have a longer period during which DUI recidivism could occur, and the latter study would have a longer pre-arrest period which would result in more variability in pre-arrest variables. These enhancements to the present study should result in models with substantially increased predictive power.

A well-planned study should be performed on the effects of any changes in sanctioning that result from the findings contained in this or the above recommended studies. A previous study (Marsh, 1989), in which drivers with two major convictions or three alcohol-related incidents were sent notices of probation with the condition that they could not drive after consuming alcohol, determined that these actions were not effective in reducing recidivism. The effect on DUI recidivism of sentencing DUI convictees with high probabilities of recidivating to alternative or more stringent treatment or sanctions should be carefully evaluated in the light of this prior study.

[9] Senate Bill 38 alcohol treatment programs are required to discuss drugs other than alcohol, but no content or duration is specified. The findings of high recidivism among DUI convictees with low BAC levels and the high incidence of drugs among convictees with BAC levels at or below 0.08% suggest that there should be requirements for both the content and duration of drug presentations.

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