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UM-HSRI-AL-74-8

ANALYSIS OF HIGH-RISK GROUPS  
FOR ALCOHOL COUNTERMEASURES

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December 1974

Final Report on Phase I

Prepared for

DEPARTMENT OF TRANSPORTATION  
National Highway Traffic Safety Administration  
Office of Driver and Pedestrian Research  
Washington, D. C. 20590

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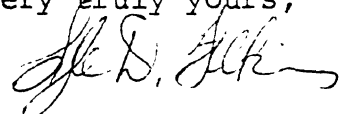
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1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle ANALYSIS OF HIGH RISK GROUPS FOR ALCOHOL COUNTERMEASURES		5. Report Date December 1974	6. Performing Organization Code
7. Author(s) L. D. Filkins, C. P. Compton, R. L. Douglass, J. D. Flora		8. Performing Organization Report No. UM-HSRI-AL-74-8	
9. Performing Organization Name and Address Highway Safety Research Institute The University of Michigan Huron Parkway and Baxter Road Ann Arbor, Michigan 48105		10. Work Unit No.	11. Contract or Grant No. DOT-HS-4-00990
12. Sponsoring Agency Name and Address Department of Transportation National Highway Traffic Safety Administration Office of Driver and Pedestrian Research Washington, D. C. 20590		13. Type of Report and Period Covered Final Report on Phase I	
14. Sponsoring Agency Code		15. Supplementary Notes	
<p>16. Abstract A 6-month (Phase-I) planning study was undertaken as the first step in a possible long-term, three-phase study. The overall study objectives are identification of groups of drivers at high risk to alcohol-related (A/R) crashes, development of predictive techniques for assigning risk factors to individuals within the groups, validation of the predictive techniques, and identification of countermeasures expected to reduce crash risks among identified drivers.</p> <p>Phase-I objectives included identification of potential high-risk groups and the development of plans for their study. Relevant literature was reviewed and data from selected in-house files were analyzed. No variables were found that unequivocally identify drivers at high risk to A/R crashes, and such drivers were found to be widely distributed. However, several variables consistently correlated with A/R crashes were found. The low incidence of A/R crashees among the general driving population was shown to create a significant identification problem that will result in a high false-positive rate among those predicted to have an A/R crash. Countermeasure programs directed to target groups known to contain a large number of false positives will necessarily be of limited scope.</p> <p>A carefully conceived and executed research program was recommended for the following target groups: A/R crashees; DWIs; blue-collar workers with high absenteeism rates; assigned-risk insureds; and divorcing persons.</p>			
17. Key Words		18. Distribution Statement	
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price



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## 1.0 INTRODUCTION

Reported herein are the results of a six-month planning effort, identified as Phase I, undertaken in preparation for a potential long-term study entitled "Analysis of High-Risk Groups for Alcohol Countermeasures." The primary objective of the prospective long-term study is to identify individuals most likely to be involved in alcohol-related (A/R) crashes. A second objective is to identify countermeasure approaches that may be expected to reduce highway accidents among identified high-risk drivers so that effective preventive action can be taken prior to crash involvement.

The specific objectives of the Phase-I planning effort were to identify potential high-risk groups and generate a detailed plan of procedures for their study. Phase-II activities, if undertaken as originally conceived by NHTSA, would have included the collection of a variety of detailed data elements about drivers within the groups identified in Phase I, and formulation of a risk-prediction technique based on these data and their analyses. Phase III would consist of a validation study of the predictive techniques, using five years of driving record followup data. These requirements\* were amplified in early discussions between technical principals from NHTSA and HSRI, and NHTSA personnel stressed the importance of addressing the pertinent benefit/cost considerations throughout the study.

The Phase-I objectives were approached by reviewing relevant literature, by analyzing various data available through

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\* RFP NHTSA-4-A611, dated 5/7/74, and Contract DOT-HS-4-00990

HSRI computerized data files, and by assembling pertinent information about Michigan's A/R crash experience. These activities have not produced any startling research results. However, the existing data, particularly when reviewed and interpreted from a benefit/cost and countermeasure-program perspective, clearly have important implications for the conduct of Phase II. The results to date and their interpretation together comprise Task 1 of Phase I and are given in Section 2 of this report.

Section 3--Phase I, Task II Planning Results--contains HSRI's recommendations regarding the conduct of Phase II. It will be seen subsequently that the activities and statement of work deriving from these recommendations are somewhat more modest in scope than those given in the original RFP for Phase II. The fundamental reason for this is that we believe it important to resolve several of the research issues uncovered during the Phase-I activities. In agreement with the RFP, we believe that considerable analytic work is called for during Phase II on the driving records of individuals within the experimental study groups. Unlike the RFP, we do not think it wise to plan for an extensive and expensive primary data collection effort on individual drivers at this time. The reasons for this position are developed in subsequent sections.

## 2.0 PHASE I, TASK I RESEARCH RESULTS

The present section contains a summary of the research findings--both those known heretofore and those newly generated--on which the recommendations contained in Section 3.0 are based. A limited review of the recent, pertinent literature was undertaken; a summary of this review follows and detailed information will be found in Appendix A. Key findings from certain analyses of in-house, computerized crash files are also given. Specific data about Michigan's A/R crash experience are presented, including costs of crashes by severity, geographic distribution, and the incidence of A/R crashes among Michigan drivers. The important issues of false positive and false negative test results--which necessarily result when imperfect predictive techniques are used for screening or diagnostic purposes--are also discussed and are related to the low incidence of A/R crashes among the driving population at large. Benefit/cost considerations are addressed briefly, and the findings are summarized in terms of the Phase II activities to be undertaken subsequently.

## 2.1 LITERATURE REVIEW

A detailed review of recent literature that provides significant background information for this study is presented in Appendix A. The literature review was organized in terms of biographical, demographic, socio-economic, and certain situational variables, and was oriented toward identifying target groups for which cost-effective A/R countermeasures could be postulated and applied.

Identifying operational target groups from the existing literature presented many problems. Studies generally are not comparable because of differing methodologies and data incompatibilities. Critical variables are often poorly measured, if at all, and comprehensive, multidisciplinary research using longitudinal analyses is uncommon. Analytic techniques have frequently been inadequate. The net result has been that useful, specific target groups with known, elevated risks to A/R crashes have not been uncovered by the literature review.

This result notwithstanding, the review has been productive, in that a number of variables were found to be correlated with A/R crashes consistently. These will prove useful both in helping to define potential countermeasure groups and for use in predictive models employed to generate risk factors for individuals within the groups. Further, methodological weaknesses characteristic of some of the studies are evident, and a discussion of these should prove useful to whatever organization undertakes Phase II.

The association of the basic demographic variables (age, sex, marital status, race) and accidents, particularly A/R accidents, has been demonstrated by the literature. The strength of this association varies from study to study, depending on the number of other variables included, the criterion variable(s), the study population, and the methodology used by the investigator. The young (16-29) male driver is consistently identified as being over-involved in accidents, while the older (30-50) male driver has been identified as the high BAC (Blood Alcohol Concentration) driver in both DWI (Driving While Intoxicated) and A/R crash populations. Divorced or separated males are over-represented in accident populations and tend to be drinking at the time of their accident. When used, socio-economic indicators have identified blue-collar workers as significant contributors to alcohol offenses and A/R crashes. Past driving and criminal records have not been shown to consistently and reliably predict future driving behavior. However, some competent studies have found that combinations of traffic and criminal offenses, including accidents, are associated with drinking and driving, while others have found no significant relationship.

Psychological tests or indexes of deviant behavior have met with mixed success when used to predict future driving behavior. Recent studies have indicated that long- or short-term stress, in conjunction with alcohol use, may precipitate behavior leading to accident involvement. Until correlations of psychological tests and personality profiles with driving behavior are shown to be stable and experimentally reproducible, the utility of

psychological indexes for predicting driving behavior remains uncertain.

The many investigations reported in the literature employ a full range of research methods for ultimate triangulation on the same end result, e.g., to understand who it is that becomes involved in an alcohol-related highway crash. In the majority of selections reviewed here, the methodologies, in the abstract, were sound and internally valid (a large number of less-than-adequate sources were excluded because of methodological deficiencies). However, the many predictive models generated or variable correlations found were of little practical value for individual or group identification. This lack of utility was the result of inadequate analytic methodology, discipline-bound data sets, data restrictions or inclusion of intercorrelated variables, and/or the failure of the investigator to determine the practical accuracy of predictions or correlations for a general population.

Many of the studies reviewed display a level of statistical analysis that is patently inadequate to address complex and variable interactive problems. Typically these studies provided measured relationships of single independent variables to single measures of crash occurrences, for groups or individuals. The bi-variate analytical situation invites numerous inferential/methodological traps. Spurious relationships, for instance, often are produced in correlational studies. If inadequate control is achieved through introduction of "control" or



intervening variables, a statistically significant but spurious correlation may persist. Thus, several statistically significant "predictors" have been found when, if those factors had been adequately controlled for, they would have been shown to be falsely or non-significantly associated with crashes. The need to predict high-risk target groups, in a way suitable for administrative use, requires that a complex and interactive phenomenon be analyzed at its own level of complexity. The relationship of one independent variable to a crash cannot logically be given high predictive weight unless it is viewed as being interactive with several other independent terms. For the most part, there is little emphasis on multivariate analyses in the literature--especially regarding the analysis of alcohol-related crashes.

Another characteristic of the literature is the variety of disciplines represented and a stubborn persistence of investigators to consider variables only within disciplinary boundaries. For example, there is no measured interaction between divided-attention task performance and acute risk-taking behavior, or socio-economic status and stressful life events, or other potentially useful correlations. The field of highway safety is far too inter- and multi-disciplinary to permit investigators the luxury of narrowly conceived research conducted according to strict disciplinary points of view.

Data restrictions identified throughout the literature review severely limited the adequacy of many investigations. This is particularly true of secondary analyses of crash, violation,

and conviction data. The problem is that pre-crash behavioral measures are rarely obtained for official records. Therefore, critical analyses of crashes are inhibited by the lack of essential information, and the studies that do have adequate behavioral data are not adequately integrated with the crash records. Integration by inference is unsatisfactory for purposes of target-group identification. Another data restriction is the inability of many investigators to obtain comparable data over a long enough time period to facilitate tests of the stability of findings over time.

Some of the investigations reviewed are hampered by the inclusion of inter-correlated and/or multi-colinear variables within the same correlational analyses. The end results of such errors of methodology are statistically impressive prediction models with little practical value. Closely associated with such methodological shortcomings is the use of self-selected populations or case-study data to develop prediction models of high-risk groups. This sort of data set frequently raises the question of generalizability.

## 2.2 ANALYSIS OF SELECTED COMPUTER FILES

The initial literature review made it apparent that too few of the studies had specifically related driver variables to A/R accidents. To fill this void to the extent possible, in-house files were reviewed to identify data sets that contained both driver-specific variables and accident-specific variables. Of the four files selected, three contain information on specific drivers or specific accidents, and one contains roadside-survey information, including BACs.

Our initial goals in analyzing those files were to:

- (1) Compare the A/R crash data in the files with the A/R variables reported in the literature;
- (2) Identify additional A/R-crash variables that were not reported in the literature;
- (3) Identify, to the extent possible, the involvement or over-involvement of target groups suggested by the literature; and
- (4) Identify new target groups or unique populations exhibiting a high frequency of drinking and driving or A/R crashes.

### 2.2.1 Description of Data Sets

The four files used as data sources were:

- (1) The Collision Performance and Injury Report (CPIR) file. This contains vehicle, occupant, and injury data for 6,060 accident cases collected by more than 30 multidisciplinary accident-investigation teams from around the country. Because the non-NHTSA teams did not report on such driver-specific variables as marital status, occupation, driving record, driver stress, alcohol usage or other driver impairment, CPIR cases missing those data were excluded from the analysis. In general, teams did not select cases for investigation based on the drinking state of the driver. Potential biases on other variables have been neglected in the

effort to associate alcohol, crash involvement, and driver characteristics. Specific biases are noted where they appear to influence the conclusions given.

(2) The Washtenaw County Alcohol Safety Action Program (ASAP) file. This contains driving records, criminal records, and program evaluation records on 3,539 alcohol offenders who participated in the program under the supervision of the Washtenaw County Courts. The driving records are complete for a 6 1/2-year period, and include an average of ten months' driving exposure after completion of the program.

(3) The Wayne County Fatality (WCF) file. This contains driving records and accident data, both precrash and crash, for 309 dead drivers involved in fatal accidents that occurred in Wayne County, Michigan, during the period July 15, 1967, through August 31, 1969.

(4) The National Roadside Survey (NRS) and National Roadside Survey Archive (RSA) files. These contain roadside survey data from all areas of the U.S. The NRS file, containing 3,698 interviews, represents a nationwide, random survey of nighttime drivers. The RSA file, a collection of Alcohol Safety Action Program roadside surveys, currently contains approximately 80,000 interviews obtained in 78 surveys from 28 ASAPs in as many states. After comparing the frequencies of variable responses to ascertain the generalizability of the NRS data, further bivariate analyses were conducted on the NRS file only.

### 2.2.2 Methods and Results

To maintain consistency and facilitate comparison with other sections of this report, the findings from the computer files are reported here first by variable and proposed target group and then summarized with respect to the literature review. The implications of the findings as they affect the remainder of the report are then discussed.

Sex. Male drivers, without exception, were over-involved in the A/R crash groups in our files. Consequently, most subsequent analyses were conducted only on male subsets. Males comprised 87.6% of the WCF population, 69.1% of the CPIR population, and 82.8% of the NRS population. Clearly, on a cost-effective basis, any countermeasure aimed at high-risk target groups should be directed at male drivers.

Race. The utility of this variable in connection with countermeasures is questionable. However, in the WCF file, 35.6% of white drivers and 23.7% of non-white drivers had not been drinking, while 53.0% of white and 64.4% of non-white drivers were above .10 BAC. This tends to support reports in the literature that non-white drivers in accident populations tend to have been drinking more often and more heavily.

Socio-Economic Level. Blue-collar workers comprised 57% of the NRS sample, 27.1% of the CPIR file\*, and 48.2% of the WCF file. This occupational class was found to be more frequently associated with driving after drinking, and with higher BACs, than

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\*This figure is probably low, due to the selection of newer-model-year vehicles for the case studies.

any other occupational class. Variables associated with occupational class, such as income level and education, also show this trend. These findings are in agreement with the literature studies that used this type of variable.

Driving Record. Two files, the ASAP and WCF, had reliable driving record data. The analysis of the ASAP data is included later under the DWI target group. The WCF driving histories did not show any unique associations. The accident rate (computed by excluding the fatal accident) was slightly higher for the fatal sample than for the general driving public, but about half the rate of the ASAP sample. High-alcohol fatalities (.15+ BAC) had a higher violation rate than those with lower BACs.

Age. Younger drivers (less than 25 years old) have consistently been reported in the scientific literature and in the popular press to be over-represented in crash populations. The common base populations from which such over-representations are measured are general population data and numbers of driving licenses. Even though the latter is the better of the two measures, its adequacy as an adequate measure of the exposed population has been challenged. Nonetheless, a finding that some group is over-represented in a crash population relative to its numbers in the licensed driving population is useful in the present context for identifying target groups. Furthermore, the more nearly ideal exposure measures, such as miles driven or nighttime miles driven, are not available.

The data sets analyzed here demonstrated, as did the literature review, that younger drivers are over-involved in the

frequency of nighttime driving and in the frequency of their accidents. Drivers under 25 years old comprised 42.2% of the NRS population and 39.6% of the CPIR crash population. Of the drivers under age 25 in the NRS file data, 18.3% of them had been drinking. In the WCF file data, 35.6% of the drivers were under age 26, and 67.3% of those drivers had been drinking.

These data can be compared with the percentages of young drivers in the U.S. and in Michigan.\* Of all U.S. male licensees in 1972, 21.8% were under age 25. (Irrespective of sex, 22.1% of all U.S. licensees were under age 25 in 1972.) In Michigan, male drivers under age 26 comprised 25.8% of all male licensees in 1972.

While the accident files are not strictly comparable, the data indicate the over-involvement of the younger driver. The CPIR data are probably not indicative of the general trend observable in the literature because of the selection criteria employed by the accident investigation teams, most of which were focussing on accidents involving new- and recent-model vehicles. Younger drivers, even when drinking, however, tend to have a lower BAC than older drivers. In the WCF fatality sample, 77.2% of drivers 26-45 years old were above 0.10% BAC, while 52.7% of the drivers under age 25 reached or exceeded that level. As suggested by both the literature and these data analyses, both the younger and older driver contribute to the A/R crash problem.

\*Mundy, A.R., Drivers Licenses - 1972, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C., 20590, 1973.

Marital Status. Data on marital status and BAC from the CPIR and NRS files are shown in Table 1. Marital status data for U.S. males 18 and older are also given.\*

In the census data, divorced and separated males together comprise approximately 4.5% of the population, while in the NRS sample they comprise 6.1% of the sober, nighttime, weekend drivers and almost 14% of the drunk drivers. Clearly, divorced/separated drivers are over-represented in the at-risk driving population and heavily over-represented in the drinking-driving population, with respect to their numbers in the general population. Even though the CPIR crash file must be approached with caution due to the selection biases, it is apparent that the divorced/separated drivers are also heavily over-involved in A/R crashes with respect to their number in the general population, with 15.3% of drunk, crash-involved drivers either divorced or separated.

A comparison of the WCF file with census data for the Detroit Standard Metropolitan Statistical Area (SMSA) produces similar results for the distribution of fatal-accident drivers by marital status. Separated/divorced males over 18 years comprise a slightly higher percentage of the population of the Detroit SMSA than of the national population - 5.3% compared to 4.5%. However, divorced/separated drivers also comprised a larger total percentage--9.9%--of the fatal population than either the

\*U.S. Bureau of the Census, Census of Population: 1970, Vol. 1, Characteristics of the Population, Part 24, Michigan, U.S. Government Printing Office, Washington, D.C., 1973.



TABLE 1. MARITAL STATUS VS. DRINKING STATUS: NRS AND CPIR FILES

	U.S. Population (Males 18 and Older)		NRS		CPIR	
	BAC .10%+	Not Drinking	BAC .10%+	Not Drinking	BAC .10%+	Not Drinking
Divorced/ Separated	4.5%	13.9%	6.1%	7.8%	15.3%	6.8%
Other	95.5	86.1	93.9	92.2	84.7	93.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

roadside sample or the crash group. Among high-BAC drivers the divorced/separated group comprised 13% of the fatal-accident drivers, or nearly 2.5 times their number in the general population.

The consistent finding that divorced/separated males are over-involved among drunk drivers and in A/R crashes, both in the literature reviewed and in the file analyses, indicates that this group offers a well-defined target group for A/R crash intervention. The high percentage of drunk, at-risk, and crash-involved drivers who are divorced or separated indicates that this group is contributing disproportionately to the A/R crash problem.

Drinking Involvement vs. Injury Severity. It has been known for some time that alcohol involvement in crashes increases as severity increases. A byproduct of the CPIR file analysis is that this result has been established with greater certainty than heretofore.

Figure 1 displays this result in terms of AIS (Abbreviated Injury Severity scale for Overall Occupant Injury Severity) and the percent within each AIS group meeting two codes for driver use of alcohol. The code values and their meaning follow.

The striking thing about these data is the positive and monotonic increase of the total Drunk- or Had-Been-Drinking curve as a function of increasing AIS. (The exception is AIS 10, "Details Unknown" for which there are only 11 drivers.) The increase is seen to hold even for the four AIS codes 6-9 for increasingly severe fatal accidents.

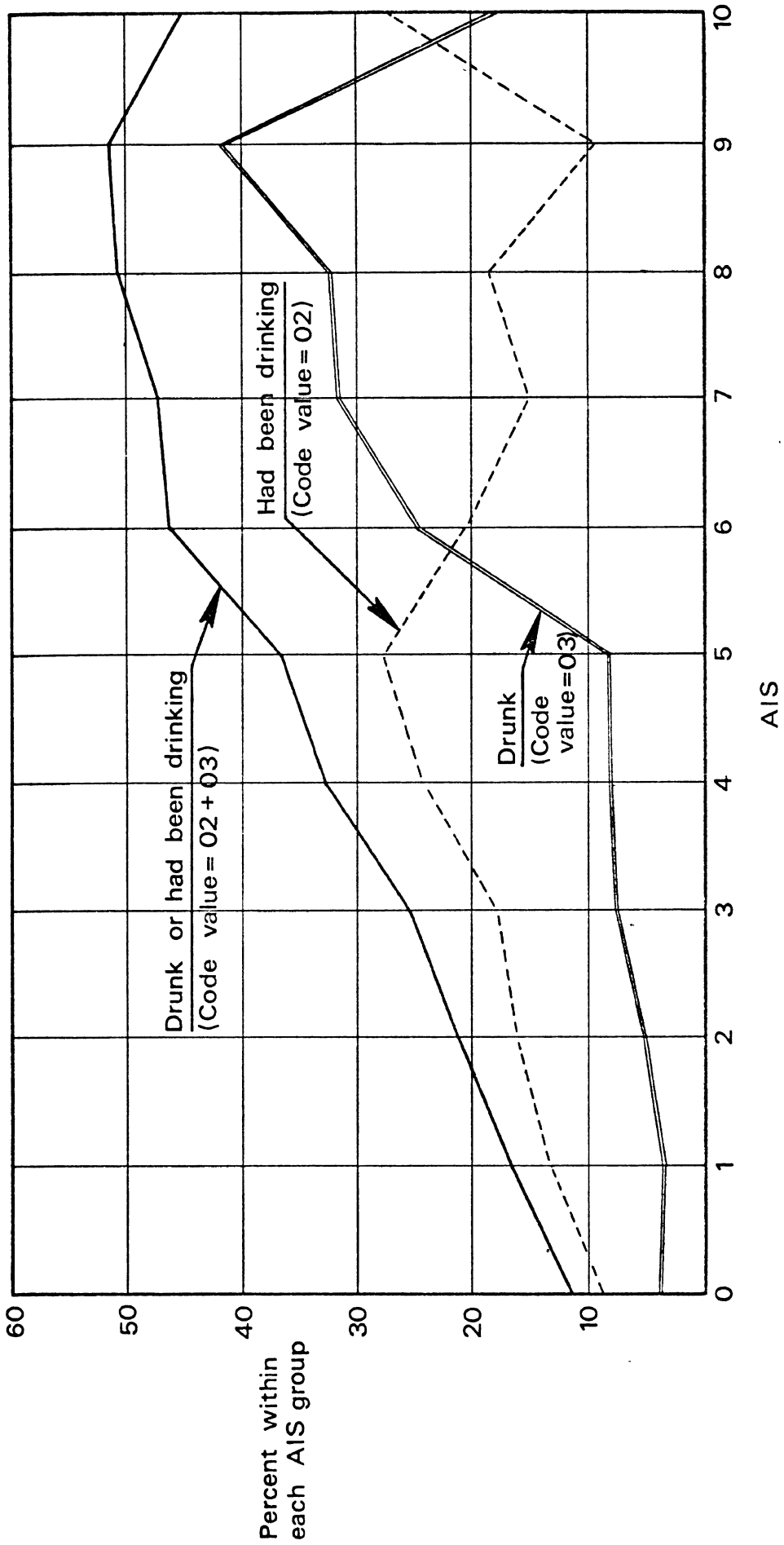


FIGURE 1. DRINKING INVOLVEMENT OF CPDR DRIVERS VS. INJURY SEVERITY

<u>AIS</u>	<u>Meaning</u>
00	None
01	Minor
02	Non-Dangerous, Moderate
03	Non-Dangerous, Severe
04	Dangerous, Serious
05	Dangerous, Critical
06	Fatal Lesions in 1 Region
07	Fatal Lesions in 1 Region + Serious Elsewhere
08	Fatal Lesions in 2 Regions
09	Fatal Lesions in 3 or More Regions
10	Fatal, Details Unknown
98	Injury Unknown
99	Injured, Severity Unknown

#### Driver Use of Alcohol

1	Not drinking or missing data
2	Had Been Drinking
3	Drunk by Local Legal Standards (Either judgmental or by BAC $\geq .10\%$ )

AIS codes 0 and most AIS 1 injuries are equivalent to police agencies' property-damage-only crashes. There are 15.34% A/R drivers in these two categories. This is in reasonably good agreement with the 13.92% A/R drivers for the 1973 Michigan statewide property-damage experience. Similarly, 47.62% of the dead drivers were HBD or Drunk, again comparing favorably with the comparable 1973 Michigan figure of 49.10%. These findings suggest that the CPIR file, despite its known weaknesses, has no catastrophic biases with respect to alcohol involvement, and that A/R inferences are possible if made with due caution.

#### 2.2.3 Target Group Identification

The by-variable findings from the computer files have confirmed the general findings reported by the literature. Our prime concern, however, is to identify groups, based on combinations of variables associated with an elevated A/R crash

risk, with respect to the general driving population. Due to the differing sample populations in each computer file and the differing nature of the variables in the files, the target-group characteristics identifiable in each file are somewhat different.

CPIR File. The groups identifiable in the CPIR file are not exactly those we might desire on the basis of the literature review. However, some of the variables are the same. Following is a list of some candidate risk groups from the CPIR file, together with some measures of their over-involvement in alcohol-related crashes, injuries, and fatalities. Some important considerations to keep in mind are that this is a crash file, so these over-involvement rates are not the same as the incidence rates discussed subsequently. Further, the CPIR file has been filtered to become a driver file of males. Thus, the base group is already at an elevated risk relative to the general driving population. In the total file remaining, 1090/4186, or 26.0% of the crashes, were alcohol-related. Of the serious injuries, 491/1427, or 34.4%, were alcohol-related.

In the Table,  $P_1$  stands for the proportion of alcohol-related crashes resulting in serious (AIS 2 or greater) injuries in that group. Thus  $P_1$  equals the number of alcohol-related serious-injury crashes in the group, divided by the total number of serious injury crashes in the group.  $P_2$  represents the proportion of alcohol crashes (all injury levels) to all crashes in the group. The columns headed by  $P_1$  and  $P_2$  thus represent a measure of over-involvement of alcohol in crashes for the particular group.

TABLE 2. OVER-INVOLVEMENT RATES FROM CPIR FILE

Potential Risk Group	P <sub>1</sub>	P <sub>2</sub>	Q <sub>1</sub>	Q <sub>2</sub>
1. Blue Collar with previous license suspension	.758	.655	.023	.013
2. Marital State other than Never Married or Currently Married	.530	.443	.058	.033
3. Blue Collar and Marital State other than Married or Single	.368	.485	.013	.008
4. Blue Collar with Previous Violation	.485	.349	.072	.057
5. Blue Collar with Previous Collision	.397	.311	.055	.044
6. Occupation other than White or Blue Collar	.313	.213	.157	.113
7. White Collar	.313	.240	.141	.110
8. Young (18-35) males in High Performance and/or Pony Cars and/or Speciality Cars	.439	.310	.150	.132
9. Blue Collar	.469	.324	.114	.089
10. Total CPIR Male Drivers	.344	.260	1.000	1.000

The columns headed by Q<sub>1</sub> and Q<sub>2</sub> are intended to indicate the contribution of the groups to the total crash problem. Q<sub>1</sub> is the proportion of serious injuries accounted for by that group, while Q<sub>2</sub> is the proportion of all crashes accounted for by that group. It should be noted that the groups are neither mutually exclusive nor exhaustive. Thus the proportions need not add to one; their sum may be either greater or less than one.

As the above table indicates, blue collar, divorced or separated, and previous violations or crashes all tend to subset groups with higher A/R crash experience than a general, male, crash population.

ASAP DATA. Driving history data from the ASAP client file are complete for 2,351 drivers arrested for either a drunk-driving violation or a Drunk and Disorderly violation. Of these

drivers, 1,554 have no A/R crash on their record for the 6-1/2 years (including the program period) of driving records available, while 797 have an A/R crash on their record for this period. Thus the 6 1/2-year A/R-crash incidence is 33.9%.

The A/R-crash group has more multiple violators (13.7% with an A/R crash, 10.7% without), more blue-collar workers (76.5% with an A/R crash, 63.2% without), and more separated and divorced drivers (25.2% with an A/R crash, 23.4% without). This gives support to the use of these variables for prediction of A/R accident involvement for a DWI target group.

An interesting subgroup of the ASAP client population consists of those drivers who entered the program with a Drunk and Disorderly conviction. This conviction does not get recorded on the driving record. 1,601 drivers have an A/R traffic conviction, 866 have a D&D, and 116 have both on their records.

TABLE 3. A/R CRASHES DURING THE 6-1/2 YEAR DRIVING RECORD PERIOD

	<u>INDIVIDUALS</u>	<u>CRASHES</u>	<u>CRASH RATE</u>
D+D Violation Only	750 ( 31.9%)	353 ( 34.0%)	$\frac{353}{750} = .471$
A/R Violation Only	1485 ( 63.2%)	611 ( 58.9%)	$\frac{611}{1485} = .411$
Both	116 ( 4.9%)	73 ( 7.0%)	$\frac{73}{116} = .629$
Total	2351 (100.0%)	1037 (100.0%)	$\frac{1037}{2351} = .441$

Those individuals with only D+D convictions have a higher rate of A/R crashes than those with only A/R traffic convictions. Those with both D+D and A/R traffic convictions have a much higher rate than either those with only D+D or those with only A/R traffic convictions. These figures may be confounded by an

occasional DUIL or D+D citation issued to a crash-involved driver, but the proportions are believed to be in error by less than 10%.

The most important point, however, is that D+D convictions do not appear on the driving record and do not involve a driving-related penalty. If the driving performance of the D+D group is similar to that of the A/R traffic group, a comparable level of intervention would seem to suggest itself, and the only means of identification of this group is the D+D conviction. Comparisons of the group with D+D convictions and the group with A/R traffic convictions show a larger percentage of blue collar and separated or divorced individuals among the D+D group.

The most interesting finding is that those individuals with D+D convictions seem to have a crash experience recorded on their driving records that is comparable to the crash experience of the individuals with an A/R traffic conviction. Since the D+D conviction is not recorded on the driving record and a driving-related penalty is not assessed, the only access to these people would seem to be through the D+D conviction on the criminal record.

SUMMARY. Support for the variables reported by the literature (social class, marital status, DWI conviction, previous accidents and violations, license suspensions, age, and sex) to be associated with crashes, and specifically alcohol-related crashes, was obtained. In addition, it was found that drivers with a Drunk and Disorderly conviction on their criminal record have an A/R-crash rate comparable to drivers with a DWI conviction on their driving record. It appears that for countermeasure inter-



vention, this group is potentially as important as the DWI drivers, especially when the Drunk and Disorderly conviction is the result of an accident or other driving violation.

## 2.3 MICHIGAN'S ALCOHOL-RELATED CRASH EXPERIENCE

Several factors pertaining to Michigan's recent alcohol-related crash experience have been examined as part of the planning effort. Michigan was selected not only because of convenience, but because it probably is as representative of the nation with respect to A/R crashes as any other single jurisdiction. Further, HSRI's experience has been that Michigan police agencies are attentive to possible alcohol involvement in crashes and that the state agencies satisfactorily record A/R crashes on accident reports and on official driving records.

### 2.3.1 Proportion and Costs of A/R Crashes by Accident Severity

Table 4 , compiled from Michigan State Police data for Michigan's 1973 crash experience,\* shows the distribution of accidents by severity and drinking involvement; row and column percentages are also displayed. An "HBD" accident is one in which at least one crash-involved driver or pedestrian was noted by the investigating police officer to "Have Been Drinking"; neither accident responsibility nor drunkenness is necessarily implied. A "HNBD" accident is one in which the investigating police officer checked the "Had Not Been Drinking" block for all crash-involved drivers and pedestrians. "NKID"--Not Known If Drinking--results from missing data on both the HBD and HNBD blocks for all relevant drivers and pedestrians. Since "Hit and Run" and "NKID" crashes overlap considerably, it is a reasonable judgment that "HBD" crashes are under-reported

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\* Michigan Traffic Accident Facts: 1973, Department of State Police, Lansing, Michigan.

rather than over-reported.

Note the following: (1) 0.6% of all crashes are fatal crashes, but 1.6% of all HBD crashes are fatal crashes; (2) 31.4% of all crashes are personal-injury crashes, but 42.9% of all HBD crashes are personal-injury crashes; (3) as severity increases for the classes, the HBD percentage, excluding missing data on this variable, increases from 13.9 to 22.3 to 49.1; (4) 16.8% of all crashes, irrespective of severity and excluding missing data, are HBD crashes.

Table 4.

Distribution of Michigan's 1973 Crashes by Severity and Drinking Involvement

<u>Fatal</u>	<u>HBD</u>	<u>NKID</u>	<u>HNBD</u>	<u>ALL</u>
Frequency	789	342	818	1949
Row %	40.5	17.5	42.0	100
Column %	1.6	0.7	0.3	0.6
Row % excl. M.D.	49.1	---	50.9	---
<u>Personal Injury</u>				
Frequency	21,525	13,762	74,998	110,285
Row %	19.5	12.5	68.0	100
Column %	42.9	26.2	30.2	31.4
Row % excl. M.D.	22.3	---	77.7	---
<u>Property Damage</u>				
Frequency	27,868	38,493	172,269	238,630
Row %	11.7	16.1	72.2	100
Column %	55.5	73.2	69.4	68.0
Row % excl. M.D.	13.9	---	86.1	---
<u>Total</u>				
Frequency	50,182	52,597	248,085	350,864
Row %	14.3	15.0	70.7	100
Column %	100	100	100	100
Row % excl. M.D.	16.8	---	83.2	---

Similar data for Michigan 1972 experience reveal exactly the same pattern, with the significant percentages varying less than 3% from year to year.

The costs of Michigan's 1973 HBD crashes are shown in Table 5 for varying estimates of the average cost of fatal, injury, and property-damage crashes.\* The striking fact to observe from this table is the percentage of HBD crash costs accounted for by fatal and injury crashes. Using NHTSA figures, 97.4% of HBD crash costs are incurred in fatal and injury crashes; the comparable figure for the National Safety Council dollar estimates is 89.8%; the RECAT committee estimates produce a 97.1% figure. Irrespective of which set of figures is used, it is clear that property-damage crashes, which make up 56% of the number of A/R crashes, account for only from 3% to 10% of the costs associated with A/R crashes. The balance of the study, therefore, should place considerably more emphasis on fatal and personal-injury crashes.

The argument above does not take into account judgments about the value of human life lost in fatal crashes nor the pain and suffering connected with personal-injury crashes. It is clear, however, that consideration of these non-economic issues would argue even more strongly for emphasis on the more severe crashes, so these issues will not be considered further.

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\* Cost data are taken from Need to Improve Benefit-Cost Analyses in Setting Motor Vehicle Safety Standards, B-164497(3), Report to the Committee on Commerce, U. S. Senate, by the Comptroller to the U. S., Washington, D. C. 20548, July, 1974.

TABLE 5. COSTS OF MICHIGAN'S 1973 A/R CRASHES BY ACCIDENT SEVERITY

	Crash Severity			Total
	Fatal	Injury	Property Damage	
Number A/R Crashes	789	21,525	27,868	50,182
% A/R Crashes	1.6	42.9	55.5	100
<u>NHTSA</u>				
\$/Crash	200,700	7,300	300	---
Millions of Dollars	158.4	157.1	8.4	323.9
%	48.9	48.5	2.6	100
<u>NSC</u>				
\$/Crash	52,000	3,100	440	---
Millions of Dollars	41.0	66.7	12.3	120.0
%	34.2	55.6	10.2	100
<u>RECAT</u>				
\$/Crash	140,000	2,750	178	---
Millions of Dollars	110.5	59.2	5.0	174.7
%	63.2	33.9	2.9	100

### 2.3.2 Geographic Distribution of A/R Crashes and Related Data

The geographic distribution of A/R crashes in Michigan was investigated to determine whether regional differences exist which might have countermeasure implications.\* Population data (1970)\*\* and motor vehicle registration data (1972)\*\*\* were tabulated as well to determine whether particular types of accidents are grossly overrepresented in certain areas of the state.

A summary of the pertinent data is displayed in Table 6. The data have been grouped by three regions: the 15 counties of Michigan's Upper Peninsula; Wayne County (Detroit and environs) and its four surrounding counties (Macomb, Monroe, Oakland, and Washtenaw) in southeastern Michigan; and the rest of the state. The column percents have been tabulated for each of the variables in question.

The table reveals that the population, motor vehicle registration, and crash data are highly correlated. For example, the Upper Peninsula--rural and sparsely populated--

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\* Crash data consisted of a 15% random sample of 1972 Michigan crash data drawn from data supplied to HSRI by the Michigan Department of State Police.

\*\* U.S. Bureau of the Census, Census of Population: 1970, Vol. 1, Characteristics of the Population, Part 24, Michigan, U.S. Government Printing Office, Washington, D. C., 1973.

\*\*\* Michigan Traffic Accident Facts: 1972, Department of State Police, Lansing, Michigan.

TABLE 6 . MICHIGAN POPULATION, MOTOR VEHICLE REGISTRATION, AND CRASH  
DATA: PERCENT BY REGION

Region	1970 Population	1972 Motor Vehicle Registrations	15% Sample - 1972 Michigan Crashes							
			Fatal	All Injury Damage	Total	Fatal Injury Damage	Total			
Upper Peninsula	3.43	3.41	4.35	3.00	3.47	3.48	4.13	5.10	4.67	
Five Southeastern Counties	51.34	47.32	33.78	55.44	47.09	49.58	33.91	52.45	46.72	48.97
All Other	45.23	49.27	61.87	41.56	49.24	46.96	62.61	43.42	48.18	46.36

contained 3.43% of the 1970 population, had 3.41% of the motor vehicle registrations in 1972, had 3.47% of the total state-wide 1972 crash experience, and had 4.67% of the HBD crash experience. Somewhat larger, although still small, differences are noted in comparing particular classes of accident severity percentages with the population and motor vehicle registration percentages. These differences might result from sampling variations or from police investigation and reporting practices, or they may reflect genuine differences in the phenomenon between the three regions. Irrespective of the source, however, it is important to note that the differences are small and that the similarities in distributions are pronounced.

The observations imply that countermeasures should be targeted on areas of high density population. This is particularly true if the cost of a countermeasure is primarily a function of the area covered and not of the number of persons exposed to it, such as mass media campaigns or increased police patrol activity. For person-oriented countermeasures, such as rehabilitation of problem drinking drivers, concentration on high population areas might also prove differentially worthwhile if the countermeasure cost per person can be reduced through administrative economies.

The lack of disproportionately high concentrations of A/R crashes in particular areas also places limitations on locally oriented countermeasures from a policy perspective. Even though such programs might have favorable benefit/cost ratios,



or theoretically even be 100% effective in reducing A/R crashes among the target group, nonetheless they can be expected to reduce a jurisdiction's A/R crash problem by no more than the proportion of the exposed population.

### 2.3.3 Incidence of A/R Crashes Among Michigan Drivers

The frequencies of prior alcohol use and associated BACs among crash-involved drivers are quite well known. However, characteristics of the general driving population experiencing A/R crashes, including its size, are much less studied. Incidence data of this type are important in this study for several reasons: to serve as a baseline against which the relative risk of high-risk groups can be measured; to assist in estimating the number of false predictions resulting when screening techniques are applied (see Section 2.5); and to assist in selecting sample sizes of subsequent study groups. Collection of additional incidence data is subsequently recommended as an integral part of Phase II.

Available incidence data have been collected to assist in Phase-II planning. These were taken directly or derived from a series of publications and informal reports generated by the Driver and Vehicle Administration of the Michigan Department of State.\* Key findings follow regarding yearly incidence of A/R crashes.

(a) Of 5,436,121 studied male and female Drivers of Record, 0.906% had at least one "Accident-With Alcohol" during 1972. The "Accident-With Alcohol" is equivalent to a positive

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\* See, for example, Michigan Driver Statistics, Report No. 6, September 1973, Michigan Department of State, Lansing, Michigan.

response on the HBD (Had Been Drinking) variable.\*

(b) Males had a 1.498% incidence of a least one A/R crash during 1972, compared to 0.213% for females, a 7:1 ratio. This fact obviously suggests that heavy if not exclusive emphasis should be placed on male study groups.

(c) The age-specific incidence of A/R crashes in 1971 peaked at 1.92% among both 22-and 23-year-old male drivers, and decreased, approximately linearly, to 0.15% among 61-year-old male drivers, increasing slightly thereafter. This clearly supports an emphasis on young male drivers.

(d) Male drivers aged 30 and under comprised 44.306% of the population of male drivers having one or more A/R crashes during 1971. This again suggests an emphasis on young, male drivers. Obviously, however, exclusive attention to the 30-and-under male drivers would have missed about 56% of the male drivers having A/R crashes during 1971. At face value, exclusive attention to the 30-and-under drivers does not seem warranted.

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\* Michigan's Official Traffic Accident Report Form, in use throughout the state, contains a Had Been Drinking (HBD), Had Not Been Drinking (HNBD) binary variable. Officers investigating crashes are charged with estimating crash-involved drivers' drinking conditions and recording their estimates, irrespective of whether a DWI citation is issued. Data derived from this variable provide the most reliable estimate of the incidence of A/R crashes currently available. The Michigan Department of State Police process all accident reports for the state and transmit selected data, including the HBD variable, to the Department of State for inclusion in the driving record of Michigan drivers.

(e) All 5-year age groups from 21-25 through 46-50 are overrepresented in A/R crashes with respect to the percentage of licensed drivers in their 5-year age group. The 21-25 group is highest at 1.461; that is, 20.208% of the A/R driver-involvements were produced by 13.834% of the studied drivers of record. This lends further support to identifying "young" and "male" as two of the stratification criteria.

Driver-involvement data for longer time periods are less detailed and subject to differing interpretations. The following table presents the percentage of males and females involved in one or more A/R crashes during the given time periods for about 100,000 sampled drivers having driving records during the 1966-1972 period.

Percentage A/R Driver Involvements Over Time

	Period Years	1972 1	1971-72 2	1970-72 3	1968-72 5	1966-72 7
Males		1.5%	2.5%	3.0%	3.1%	3.5%
Females		0.2%	0.4%	0.4%	0.5%	0.5%
Males: Yearly Mean		1.5%	1.2%	1.0%	0.6%	0.5%

The decreasing yearly average driver-involvement percentage (last line) is interesting, but it raises more questions than it resolves. Several explanations are possible:

1. Sampling procedures may have resulted in a larger population of 1972 drivers than for earlier years. So far as known, this is not the case.

2. Increased attention to A/R crash investigation and reporting from 1966 to 1972 may have resulted in increases of the reported phenomenon without a real increase in the phenomenon itself. This possibility cannot be ruled out.

3. The occurrence of an A/R crash in earlier years may have lowered the probability of a subsequent A/R crash for the same drivers below that of the general driving population. In other words, the probability of a second A/R crash among drivers having experienced one A/R crash may be less than that of the first A/R crash among drivers not yet having had one.

4. Since drivers in A/R crashes--not A/R crashes themselves--are being enumerated, it is possible that a significant number are recidivists. A driver with two or more A/R crashes would be counted only once during any given period, so that the longer time periods would exhibit artifactually lower percentages of average A/R driver involvements.

Items 3 and 4 are clearly important research issues with significant countermeasure implications, and their investigation is recommended during Phase II. Irrespective of their resolution, it is important to observe that the incidence of driver involvements in all A/R crashes, even among males and over extended periods of several years, is low.

## 2.4 INCIDENCE, PREDICTIVE CAPABILITY AND FALSE PREDICTIONS

Incidence, in the present context, is the proportion of drivers experiencing an A/R crash per unit time; it is a "given" and not subject to the control of the investigator. Predictive capability refers to the identification of potential A/R crashes in a group by applying a screening tool or diagnostic technique to the members of the group. False predictions are the inevitable result of imperfect predictive devices and are of two kinds: false positives, incorrectly predicting that an A/R crash will occur when it in fact will not, and false negatives, failing to predict that an A/R crash will occur when it will. These three concepts are central to this study and they are highly inter-related, both mathematically and in an operational, counter-measure sense.

The basic concept of this program is that groups and individuals within groups who have high risks of becoming involved in A/R crashes can be identified. If this is so, then specific countermeasures could be applied to identified high-risk individuals to lower their risk or prevent them from being involved in the A/R crashes.

The basic steps in achieving this goal are conceived of as:

1. Identify groups with high risk to A/R crash involvement.
2. Use a predictive model on each group to identify individuals with a high risk. This involves collecting additional data on all individuals in the target groups for input to the predictive model.
3. Develop appropriate countermeasures for the high-risk

individuals within each group. This will include trial applications and development of measures of effectiveness for evaluating each proposed countermeasure.

4. Determine the cost and the effectiveness of the proposed countermeasures.

5. If appropriate, apply the countermeasures to the selected individuals in the target groups.

Decisions must be made at several stages in such a program. In particular the ultimate decision of whether to institute the countermeasure program in a particular group is of paramount importance. The following model provides a method for a type of cost-benefit analysis to measure the utility of implementing a particular countermeasure. The implications of the model are also useful in determining feasibilities of target groups.

For clarity of notation and discussion, attention is restricted to one target group. In practice, each potential target group would be considered individually, so this results in no loss of generality. The various parameters, such as incidence, selectivity, efficacy, and total number of individuals will, of course, vary from group to group.

The following notation will be used:

$I$  = incidence of A/R crashes in the target group per unit time,

$M$  = number of drivers in the target group,

$Y$  = predictive test indicates at least one A/R crash per unit time,

$N$  = predictive test indicates no A/R crashes,

T = the subject in question will in fact have at least one A/R crash, and

F = the subject will in fact not have any A/R crashes.

Two parameters of the predictive test to be applied to the target group in question can be defined: the sensitivity and the selectivity.

The sensitivity of a predictive test is the probability that the test will correctly identify individuals who will have at least one A/R crash during some specified period. In symbols,

$$\text{Sensitivity} = P(Y|T),$$

or the probability that the test correctly predicts the A/R crash, given that the individual will in fact have an A/R crash. Similarly, the selectivity of a predictive test is the probability that the test will correctly identify those individuals who will not have any A/R crashes in the specified period. In symbols,

$$\text{Selectivity} = P(N|F),$$

or the probability that the test correctly predicts no A/R crashes, given that the individual will have no such crashes in the specified period. Sensitivity and selectivity are related. In general it is possible to improve either at the expense of the other. However, in order to improve both simultaneously, a new procedure must be found.

When a predictive test is applied to a group, it is important to be able to estimate the false positive rate. This is more clearly explained by the following table.



		Actual Occurrence (future)		
		T	F	
Test Result (now)	Y	a	b	a+b
	N	c	d	c+d
		a+c	b+d	M

A false positive is an individual who is predicted to have an A/R crash, but who in fact does not. The number of these indicated in the table is b. A false negative is an individual who is predicted to have no A/R crashes, but who in fact has one or more. The number of these indicated in the table is c. Then the false-positive rate is  $b/(a+b)$  and the false-negative rate is  $c/(c+d)$ . In symbols, the probability of a false positive is

$$\text{False positive} = P(F|N),$$

or the probability that the individual does not have an A/R crash, given that the test was positive for that individual. The symbol for a false negative is

$$\text{False negative} = P(T|N),$$

or the probability that the individual does have an A/R crash given that his test result was negative.

The false-positive and false-negative rates can be calculated from the selectivity, sensitivity, and incidence in the target group according to the following formulas which follow from Baye's theorem.

$$P(F|Y) = \frac{P(Y|F) \cdot (1.0 - I)}{P(Y|F) \cdot (1.0 - I) + P(Y|T) \cdot I}$$

and

$$P(T|N) = \frac{P(N|T) \cdot I}{P(N|T) \cdot I + P(N|F) \cdot (1.0 - I)}$$

The false-positive rate is plotted as a function of the incidence in Figures 2, 3, and 4 for various values of the sensitivity ( $R_1$ ) and the selectivity ( $R_2$ ) of the predictive procedures to be developed. Both the false-positive rate and the false-negative rate are shown in Table 7 for selected values of the same parameters.

The figures and table reveal a number of important characteristics. First it should be noted that relatively optimistic values of the sensitivity and selectivity have been used, ranging for illustrative purposes from 0.5 to 0.995. For the higher values of these two parameters--say 0.9 and higher, equivalent to exceptionally good predictive devices--the false-positive rate is highly non-linear as a function of the incidence of A/R crashes among the group under investigation. As the incidence decreases and approaches zero, the false-positive rate approaches unity, even for sensitivity and selectivity values of 0.995. Intuitively this is clear because, if the incidence is zero--that is, there are no A/R crashes among some particular group--then any prediction of the occurrence of an A/R crash must be false, and the false-positive rate must be one.

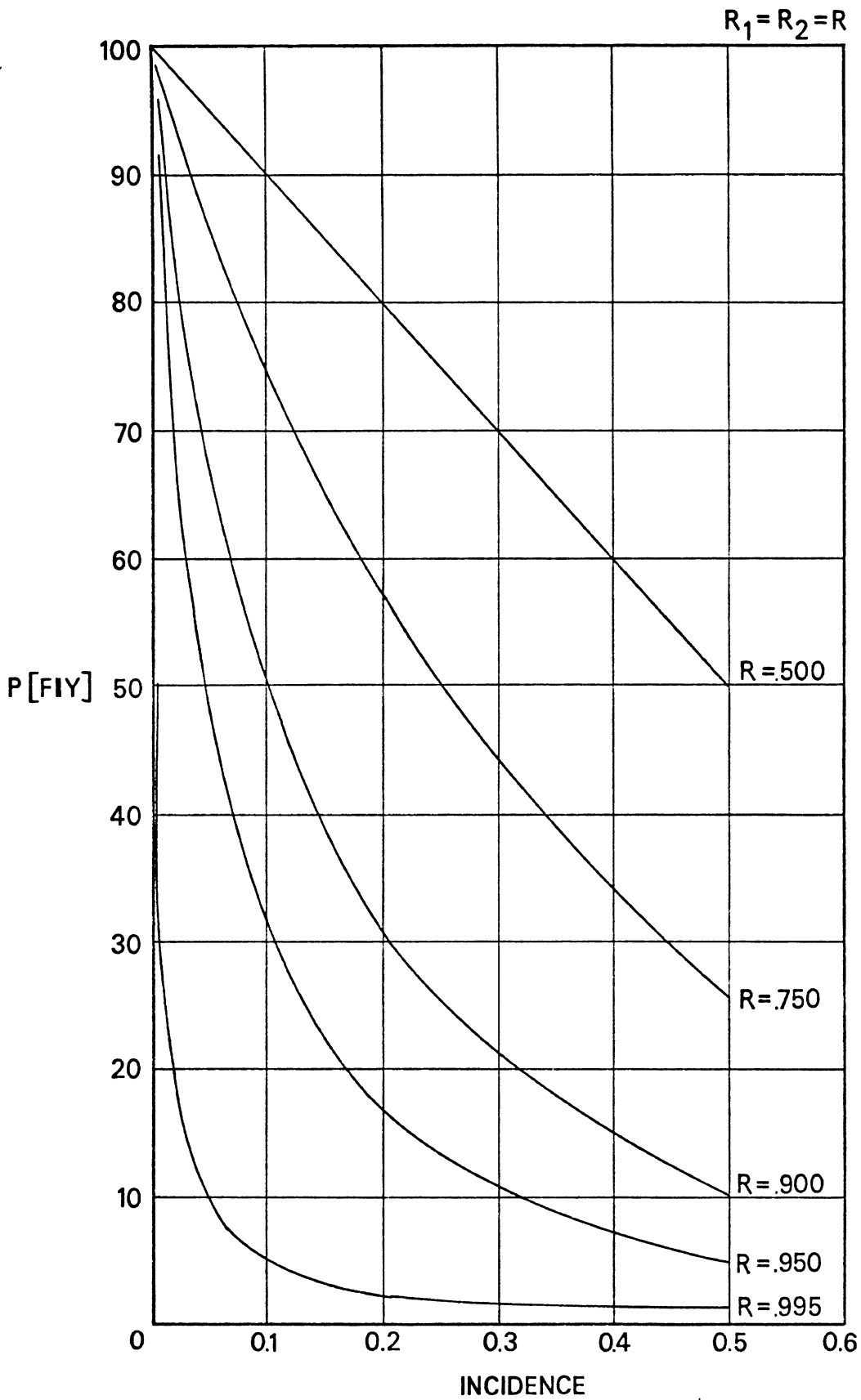


Figure 2. FALSE-POSITIVE RATE VS. INCIDENCE FOR EQUAL AND VARYING SENSITIVITY AND SELECTIVITY VALUES

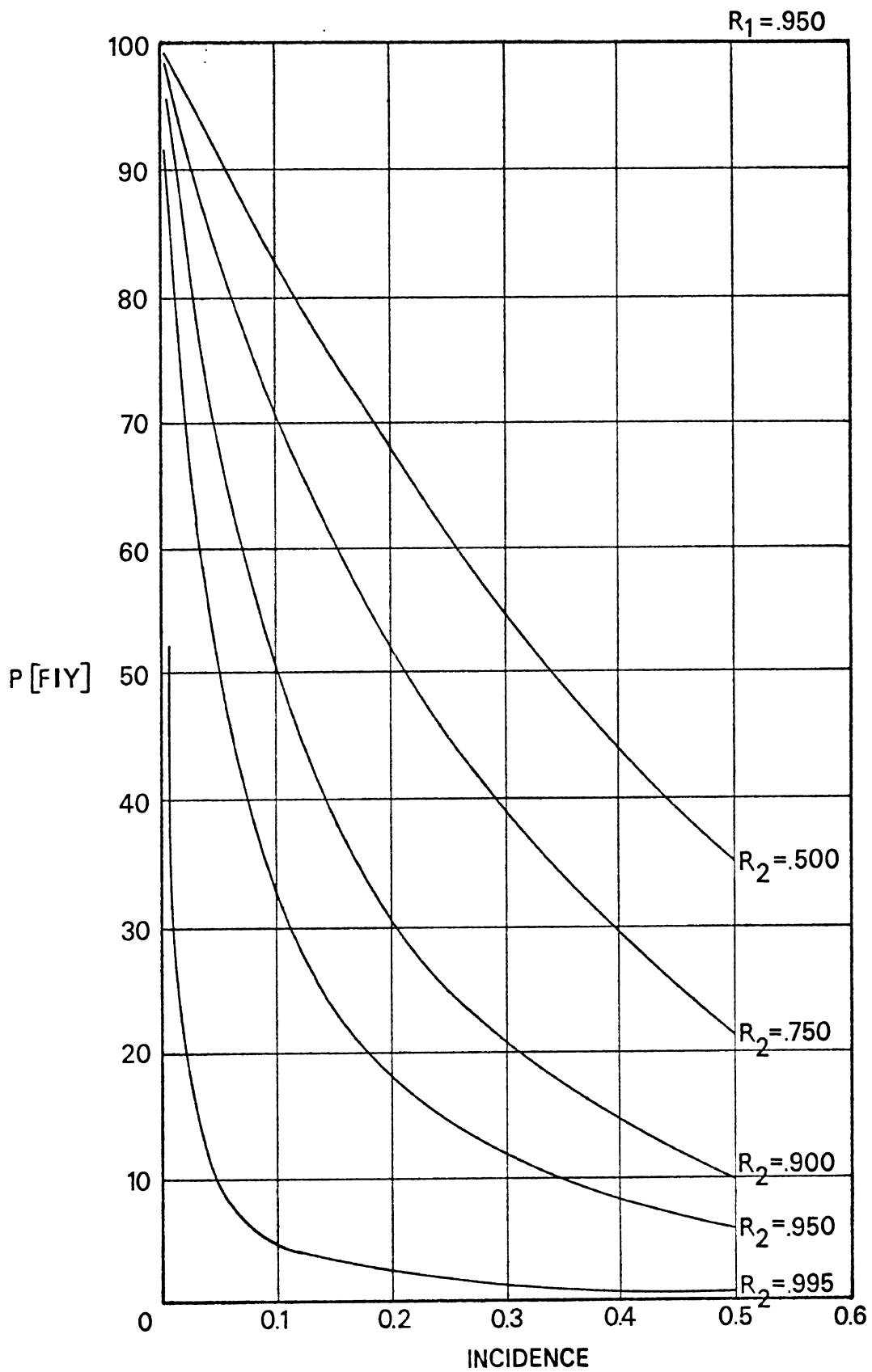


Figure 3. FALSE-POSITIVE RATE VS. INCIDENCE FOR SENSITIVITY = 0.95, VARYING SELECTIVITIES

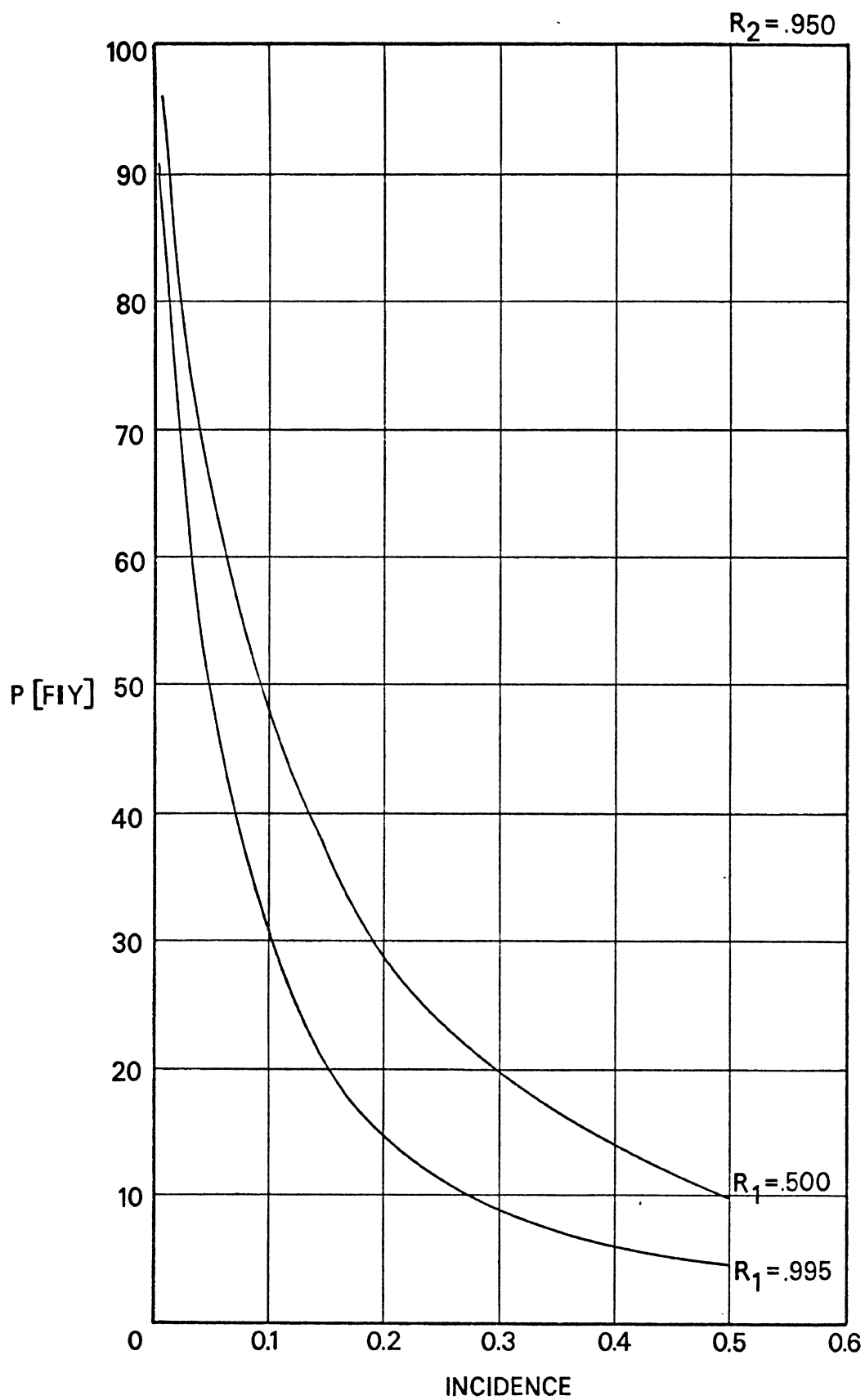


Figure 4. FALSE-POSITIVE RATE VS. INCIDENCE FOR SELECTIVITY = 0.95, VARYING SENSITIVITIES

TABLE 7. FALSE-PREDICTION RATES FOR SELECTED PARAMETRIC VALUES

<u>Incidence</u>	<u>Sensitivity and Selectivity</u>	<u>False Positive Rate (%)</u>	<u>False Negative Rate (%)</u>
.005	.995	50	.002
	.95	91	.03
	.9	96	.06
	.75	98	.2
.02	.995	20	.01
	.95	72	.1
	.9	84	.2
	.75	94	.7
.05	.995	9	.03
	.95	50	.3
	.9	68	.6
	.75	83	2
.1	.995	4	.06
	.95	32	.6
	.9	50	1
	.75	75	4
.25	.995	1	.2
	.95	14	2
	.9	25	4
	.75	50	10
.5	.995	.5	.5
	.95	5	5
	.9	10	10
	.75	25	25

## 2.5 FALSE PREDICTIONS: GENERAL IMPLICATIONS

False predictions are important in considering countermeasure programs from several perspectives. In a philosophic vein, it should be noted that false positives imply that some individuals who would not experience an A/R crash would presumably be subjected to a countermeasure program. Such a program, with few exceptions, typically involves at least some inconvenience or loss of time to the targeted drivers. Either of these would be perceived by some as infringement, however slight, of their civil liberties. This objection would seem to be particularly important when it is remembered that countermeasure intervention before the fact of an A/R crash is under consideration, with the target group almost certainly defined because of its statistical association with A/R crashes. Further, there can be no deterministic "proof" that an A/R crash will occur in the future even for true positives. (The occurrence of an A/R crash to a false positive is a contradiction in terms.) Further, Professor J. W. Little raised, over six years ago, a fundamental question about society's legal stance in precisely this situation:

From a legal point of view the task of creating new countermeasures for an old problem, however difficult that may prove, is a less profound problem than that implied by an attempt to impose a legal restriction on a class of individuals defined solely in terms of some probability that, unrestricted, they may do some social harm in the future.\*

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\* Little, J. W., "Control of the Drinking Driver: Science Challenges Legal Creativity," American Bar Association Journal, Vol. 54, June, 1968, p. 558.

The issue remains unresolved. From still a different perspective, the expenditure of countermeasure resources on false positives is at best wasteful, and at worst it can lead to a false sense of security that the A/R-crash problem is being "solved."

On the other hand, the effect of a false negative is to exclude from countermeasure attention a person who will have an A/R crash some time in the future, a crash that might have been preventable. Clearly this situation is to be avoided if possible.

The trade-off between the false-positive and false-negative rates depends on what seriousness is assigned to the crash event and on the stringency of the proposed countermeasure. The more serious the consequences of failing to apply a countermeasure to an individual and thus failing to prevent an accident, the smaller the false-negative rate should be. The more stringent the countermeasure (for example, revocation of driving privileges or vehicle registration) the lower the false-positive rate must be. The false-negative rate is closely related to the incidence of crashes. If the incidence of A/R crashes remains quite low in the target group, the more serious concern will be the false-positive rate. Table 7 shows that the false-negative rate remains below 5% unless the incidence of A/R crashes becomes greater than 10% in the target group. Currently we feel that the incidence of A/R crashes in the target groups will remain relatively low, and consequently the false-positive rate will be the more important. This need not be the case, however, and the consequences of a false negative would be viewed by some as more serious than the consequences of a false positive.



The quantitative implications of these facts for the problem at hand are also significant. From material presented earlier it will be recalled that the yearly incidence of at least one A/R crash among Michigan males is about 1.5%, and that the seven-year incidence among Michigan males is about 3.5%. Further, fatal and personal-injury A/R crashes--of prime concern because they account for over 90% of the costs associated with A/R crashes--comprise less than half the A/R crashes which occur. Therefore, the incidence of the crashes of concern among Michigan males is something less than 2%.

Table 7 shows that the false-positive rate for an incidence of 0.02 ranges from a minimum of 20% for prediction rates of 0.995 to 94% for prediction rates of 0.75. The first combination is not reasonable because the scientific community cannot realistically aspire to predictive techniques that are so close to perfection. The second situation is not much better, in that the false-positive rate of 94%--that is, 94 of 100 drivers predicted to have an A/R crash would not experience one--would create a most complex operational situation. It would indeed be difficult to postulate and implement countermeasures that would be cost-effective. The costs would be elevated simply because the 94% false positives would be indistinguishable from the 6% true positives, and they would have to be treated the same from a countermeasure perspective. One would also estimate that the benefits would be low, largely because the range of countermeasures to be applied to a group known beforehand to contain a large number of false positives would necessarily be restricted.

This somewhat gloomy outlook is modified extensively, however, if the initial incidence among the target groups is increased. For example, an incidence of 0.25 and a sensitivity of 0.9 produce a false-positive rate of 25%, the same as for an incidence of 0.5 and a sensitivity of 0.75. Such a false-positive rate might be acceptable for at least some countermeasures, such as mandatory driver-education courses or enforced attendance at didactic alcohol-education lectures; however, it would clearly be too high for more stringent countermeasures, such as revocation of driving privileges.

The final result of these considerations is that the initial incidence of A/R crashes among the target groups must be as high as possible, perhaps with risk factors of ten times that of the driving population at large. This, of course, is the fundamental thrust behind the whole study and is not a new concept. However, the preceding and following work provide a quantitative framework, heretofore lacking. This need for high and known incidence among the target groups is the primary reason why we believe that the initial thrust of the Phase-II activities must be strongly oriented to establishing, as accurately as possible and much more definitively than has been possible during Phase I, the risk factors of all candidate groups under consideration.

## 2.6 FALSE PREDICTIONS AND BENEFIT/COST CONSIDERATIONS

The implementation of any proposed countermeasure involves certain costs. Let  $C_0$  denote the overhead cost of formulating, implementing, and administering; let  $C_1$  denote the cost per individual of applying the countermeasure; and let  $C_2$  denote the cost of inconvenience to those individuals for whom the countermeasure was unnecessary. Then the total cost of implementing a countermeasure in a target group of size  $M$  is given by

$$CC = C_0 + MC_1 [P(Y|T) I + P(Y|F)(1.0 - I) + \\ + MC_2 P[Y|F](1.0 - I) .$$

If the cost per alcohol-related crash is assumed to be  $K$ , then the cost to society if no countermeasure were implemented would be

$$CD = K \cdot M \cdot I$$

that is, the product of the cost per crash times the expected number of crashes. The expected number of crashes is the number of drivers times the incidence (crashes per driver). The cost per crash,  $K$ , can be taken to be the cost per fatal crash, the cost per injury crash, the cost per property-damage crash, or some weighted combination of all of these. The different severities of crashes could also be assigned different costs,  $K_i$ , and the incidence, selectivities, and sensitivities could be determined separately for each type of crash. This would lead to a rather more complicated but tractable model. As discussed before, the major costs are incurred in injury and fatal accidents. Since

there are relatively few fatal accidents, the most practical procedure is to choose a single K to represent these accidents.

If the proposed countermeasure were perfectly effective, the comparison of the two costs above would provide the rationale for implementing, not implementing, changing the countermeasure, or improving the predictive test. However, countermeasures are not perfect, and they can be expected to prevent only some portion of the alcohol-related crashes which would otherwise occur.

Let  $e$  denote the efficacy of a proposed countermeasure. By this we mean that if the particular countermeasure were applied to  $n$  individuals who would otherwise have an alcohol-related crash in the period,  $e \cdot n$  accidents would be prevented by applying the countermeasure. If a proposed countermeasure has efficacy  $e$ , then if it is applied to those individuals in a target group of size  $M$  for whom the predictive test indicates "Y", the expected benefit will be

$$B = K \cdot M \cdot e \cdot P(Y|T) \cdot I$$

and this is the amount which must be balanced against the cost of the countermeasure,  $CC$ .

It should be emphasized that many of the parameters to make a useful benefit/cost comparison are presently unknown. The efficacy of any given countermeasure can at present only be guessed at. Estimation of the efficacy would require a carefully controlled evaluation study. The costs of implementing various countermeasures are imperfectly known; restriction of

the countermeasures to predicted individuals in target groups is one attempt to reduce the cost by limiting the number of individuals. Restriction of countermeasure efforts to areas of high population density might be a means of reducing  $C_0$ . The incidence in the target groups and the selectivity and sensitivity of predictive models have yet to be determined. Consequently the false-positive and false-negative rates are also unknown.

Certain generalizations can be made from the formulas. The larger the cost of an accident,  $K$ , the more attractive a countermeasure intervention is. Also, the larger  $K$  is, the more serious the false-negative cases area, since these cases are excluded from receiving the countermeasure by the application of the predictive model. The better the predictive model that can be developed, the better any type of countermeasure program would be, both in terms of preventing A/R crashes and in terms of avoiding application of an unnecessary countermeasure to a large group of persons. The larger the cost,  $C_2$ , of applying a countermeasure unnecessarily becomes, the smaller the false-positive rate must be. For any proposed countermeasure,  $K$  and  $C_2$  can be balanced in conjunction with the predictive model to set the cutoff score for application of the countermeasure. Reduction of any of the costs,  $C_0$ ,  $C_1$ , or  $C_2$ , will obviously improve the utility of a countermeasure. Finally, the more effective the countermeasure, the better it will appear in a benefit/cost analysis.

One of the difficulties in utilizing a predictive model for the selective application of a countermeasure program is that the predictions of the model apply properly to groups, not to individuals. If a target group can be identified which has a 25% incidence of A/R crashes per year, then this means that on the average, 25% of the individuals in that group would have an A/R crash in the subsequent year. Not all individuals in the group have the same 25% chance of experiencing an A/R crash, but it is not possible with the information at hand to distinguish which individuals in the group have relatively higher and which relatively lower chances. Consequently, they are all assumed to have an equal chance, and as a result, the particular 25% who will experience an A/R crash are regarded as a random quarter of the original group.

Further, no countermeasure program is perfect. The countermeasure can be expected to prevent only some fraction of the A/R crashes in the group. Thus a successful countermeasure might reduce the incidence in a predicted target group from 25% to 10% per year. However, the 10% of the group which would be expected to experience an A/R crash would still be regarded as a random 10% subset of the group. It cannot be claimed that the countermeasure prevented any particular A/R crash from occurring, only that it reduced the group incidence, and, as a result, the average individual risk for persons in that group.

Once a target group is identified, a predictive model would be used to select individuals from the group for the application of a countermeasure. The group incidence and the selectivity and

sensitivity of the predictive model determine the rates of false positives and false negatives. The selectivity and sensitivity of the model can be adjusted somewhat. Either can be improved at the expense of the other, so the false-positive and false-negative rates can be balanced against each other.

It is instructive to consider an example. Suppose that a target group with an incidence of 25% A/R crashes per year has been identified. Suppose further that a countermeasure for this group has been developed which is 60% effective. That is, it would reduce the incidence from 25% to 10% per year if applied to the entire target group. This may not be desirable or feasible because of cost or legal considerations, however, and it may be desired to use the predictive model to identify individuals in the group and apply the countermeasure to a subset of these identified individuals. Suppose that one possible criterion for application of the countermeasure results is a sensitivity and a selectivity that are both estimated to be 75%. According to Table 7 this would result in a false-positive rate of 50% and a false-negative rate of 10%.

The countermeasure is applied to those individuals whose score generated by the predictive model is above a specified value. This is 75% of the "true positives" and 25% of the "true negatives", on the average. Thus the countermeasure will be applied to  $\frac{3}{8}$  of the original target group, this being the number expected to score positive on the prediction. Among those predicted as positive by the model, the incidence would be 50%, which is reduced to 20% by the application of the countermeasure. Among the

rest of the initial target group, the incidence is 10% and remains at 10%, since no countermeasure is applied. Combining these results, it will be seen that the new, overall incidence of A/R crashes in the target group is 13.75%. This is to be compared to 25% if no countermeasure were introduced and 10% if the countermeasure were applied to the entire group instead of only 3/8 of it.

The advantage of using the predictive model as described was to avoid applying the countermeasure to 5/8 of the target group. The disadvantage was that the resulting incidence of A/R crashes was 13.75% instead of the 10% which could have been achieved by applying the countermeasure to the entire group. Whether the procedure was beneficial or not depends on the relative costs of applying the countermeasure unnecessarily and of failing to prevent A/R crashes. Of course, it may have been that the costs associated with applying the countermeasure to the entire group were prohibitive. In this case the effect of the predictive model was to enable the countermeasure to be applied at all.

Inspection of Table 7 indicates that the false-positive rates are much larger than the false-negative rates (if the sensitivity and selectivity of the model are taken equal) unless the incidence in the target group becomes quite high. It should be noted that with any model, the false positives can be completely eliminated by ignoring the results of the test and not applying the countermeasure at all. In this case, the false-negative rate is the incidence in the group. Similarly the false negatives may be eliminated by regarding all individuals



as positive. The false-positive rate then becomes one minus the incidence. For stringent countermeasures, the false-positive rate may well be the more important. On the other hand, the example illustrates that the effect of false negatives could still be important.

The estimation of the incidence rates for the various target groups is of crucial importance. This is emphasized in the suggested approach to Phase II. The determination of the predictive model follows in importance. It is anticipated that this model will take the form of assigning a score to each individual. This score will be determined by some combination of the various predictive variables which will be measured on the individuals in the target groups. From this score a prediction criterion would be determined for prediction of risk and subsequent application of a countermeasure. For example, large scores might correspond with high risk, and the decision would then be to apply the countermeasure to all individuals in the target group whose score exceeded a selected value. The choice of this value would affect the sensitivity and the selectivity of the predictive process and would be made after consideration of the effects on the false-positive and false-negative rates in conjunction with the stringency of the countermeasure and the assigned seriousness of an A/R crash. After the predictive model has been developed, various efficacies for countermeasures may be postulated--or estimated for specific countermeasures. The administrative and other costs of a proposed countermeasure could be estimated and the preliminary benefit/cost analysis performed.

## 2.7 OVERVIEW AND SUMMARY OF PERTINENT FINDINGS

The role of alcohol as a contributing factor to crashes of all severities--particularly fatal crashes and to a lesser extent personal-injury and property-damage crashes--is well established. It is so pervasive that it would seem a straightforward task to identify a reasonably high proportion of the drivers who will become involved in A/R crashes and take before-the-fact, preventive action.

The data in the preceding sections suggest, however, that the task confronting the research and operational communities is not a simple one by any standard. A/R crashes and "crashees" are everywhere; geographically, they are distributed throughout Michigan in about the same proportion as the general population. Sex is by far the most distinguishing feature of A/R crashees; we are concerned primarily, but not quite exclusively, with male drivers. Age is also a distinguishing characteristic; we should be concerned with young drivers for a number of reasons, but certainly not to the exclusion of older drivers. Marital status is also a distinguishing feature; divorced and separated persons are significantly over-represented among A/R-crash populations with respect to their number in the general population, but they comprise a relatively small part of the A/R-crash problem. Blue-collar workers--clearly a large part of the general population--are somewhat over-represented among A/R crashees; their over-representation is not so preponderant, however, that they should be the exclusive target of future countermeasure

efforts. Driving-record variables, such as prior DWIs, can help to identify A/R crashees, and their use is surely called for in the risk-prediction models to be developed subsequently. Like other variables under consideration, however, they are not adequate if used alone, and they should be coupled with other variables in multivariate predictive models. In summary, it is probably true that A/R crashees are more easily characterized by their heterogeneity than by their homogeneity, and that their similarities to the non-A/R-crash group are more pronounced than their differences.

The pervasiveness of alcohol as a primary contributing factor to crashes might also lead to the conclusion that a large percentage of drivers will experience an A/R crash in any given year. Based on Michigan's experience this is far from true. Only about 1% of Michigan drivers will have an A/R crash (of any severity) that is reported as such by an investigating police agency and subsequently recorded on their driving records. This already low incidence of drivers-of-interest is further cut in half because fatal and personal-injury crashes, whose costs comprise over 90% of the costs of all A/R crashes, comprise only about 45% of the number of A/R crashes.

These two summary facts together--the lack of highly distinguishing characteristics of A/R crashees and their low incidence among the driving population--pose a formidable identification problem. The first implies that risk-prediction techniques are likely to be considerably less accurate than desired. The second implies that, even with very good risk-prediction

instruments on hand, the false-positive rate can easily approach 50% or so.

In moving from the research to the operational realm, a high false-positive rate suggests that cost-effective countermeasures directed to identified, high-risk drivers may not be easily formulated. The potentially large number of false positives, indistinguishable from the true positives, will require that more drivers be "treated" than necessary, and this will increase countermeasure costs. A known, high false-positive rate also suggests that a very limited range of countermeasure options will be open to policy makers and program planners to alter the undesired behavior leading to A/R crashes. It is reasonable to conclude, therefore, that low countermeasure effectiveness is likely to result. If these conjectures are realistic then benefit/cost ratios will be low.

This overview, while reconfirming the common-sense conclusion that panaceas to the problem at hand will not be forthcoming, in no way implies that the research and operational directions implicit in the study are unsound. An inability to solve the A/R-crash problem in one fell swoop simply does not establish that cost-effective approaches for dealing with a portion of it also do not exist. Distinguishing variables of A/R crashes do exist, even on a univariate basis, and it is likely that combinations of interactive variables also exist which even more sharply distinguish high-risk (to A/R crashes) drivers from others. Multivariate analytical procedures continue

to become more powerful, and with them is the promise that risk-prediction models, operating on key distinguishing variables drawn from a variety of disciplines, can identify drivers with elevated risks to A/R crashes.

The costs of not solving the A/R-crash problem continue to be exceptionally high. Our judgment is that a carefully planned and executed program along the overall lines identified in the original RFP, seen not as a panacea but as a cost-effective approach to a part of it, continues to be a sound research investment. Our approach to the next step in such a program is spelled out in the next section.

### 3.0 PHASE-I, TASK-II PLANNING RESULTS

The preceding section has reported the research findings and their interpretation which form the basis for our recommendations regarding the content and conduct of Phase II. The current section reports these recommendations directly in the form of a proposed Phase-II work statement and discussion of the work statement.

In the introductory section it was observed that HSRI was recommending a somewhat more modest set of Phase-II activities than those originally included by NHTSA in the RFP for guidance in the preparation of the Phase-I proposal. The basic thrust of our recommendations coincides with those contained in the RFP with respect to the gathering and analysis of driving record data for individuals among the high-risk groups. However, the risk factors of the candidate target groups should be established with much more confidence than is currently known, both in quantifying the risks and in establishing the quantitative estimates with acceptable statistical precision. Until this is done, therefore, we believe that it is unnecessary, and potentially inefficient, to plan for primary, detailed data collection on individual members of the high-risk groups.

#### 3.1 PROPOSED STATEMENT OF WORK: PHASE II

##### 3.1.1 Task I: Analysis of Random Sample of Michigan Drivers

- a. Obtain, in cooperation with the Michigan Department of State, a one-percent (1%) random

sample of Michigan driving records. Include for each sampled driver all data in the Department's Master Driving Record.

b. Build the sample of driving records into computerized data files consistent with the HSRI data analytic system.

c. Determine the 1-year, 3-year, 5-year, and 7-year incidence of alcohol-related events (alcohol-related crashes by injury severity, Driving Under the Influence of Liquor convictions, and Driving While Visibly Impaired convictions), among male and female drivers and by selected demographic variables.

3.1.2 Task II: Analysis of Driving Records of Drivers with Alcohol-Related Crashes

a. Obtain, in cooperation with the Michigan Department of State, a census (or a random sample of size 2,000, whichever is smaller) of driving records containing at least one alcohol-related crash on the Master Driving Record.

b. Build computerized data files and analyze the driving records, including but not limited to the following topics: recidivism rate among alcohol-related crashees; incidence of

drivers having a second alcohol-related crash on their driving record; relationship between alcohol-related crashes and other variables contained in the driving record, such as age, sex, other crashes, alcohol-related convictions, and other convictions on the driving record.

3.1.3 Task III: Analysis of Driving Records of DWI Drivers

a. Repeat the procedures and analyses of Task II above for a sample of drivers convicted of DUIL or DWVI.

b. Correlate and compare the findings from Task II and this task, so that the relationships between persons with A/R crashes and those with A/R convictions is thoroughly understood.

3.1.4 Task IV: Analysis of Driving Records of Blue-Collar Workers

a. In cooperation with a large industrial firm in southeastern Michigan, obtain a random sample of at least 1,000 male, blue-collar workers and sufficient identifying data so that their driving records may be retrieved from the Michigan Department of State.



- b. From the same firm, obtain either a census or a random sample of 1,000 male, blue-collar workers with high rates of absenteeism.
- c. Obtain the driving records of the subjects in (a) and (b) above and determine the incidence of both alcohol-related crashes and alcohol-related convictions.
- d. Compute risk factors for the groups in (a) and (b) above, relative to each other and to the random sample of Michigan drivers analyzed in Task I.

3.1.5 Task V: Analysis of Driving Records of Assigned-Risk Insureds

- a. In connection with an insurance underwriting firm, and with the approval of the State of Michigan Insurance Commissioner, obtain a random sample of 1,000 drivers from the assigned-risk insurance pool of the State of Michigan.
- b. Obtain the driving records of the subjects, determine the incidence of A/R crashes and convictions, and compute risk factors.

3.1.6 Task VI: Analysis of Marital Stress and Alcohol-Related Crashes

a. Identify Michigan residents filing for divorce in Wayne, Oakland, and Washtenaw Counties during a time period sufficient for the population of filees to approach 1,000 individuals (approximately 10 months). The Wayne County sample selection will be in cooperation with the Marital Health Study of the Program for Urban Health Research, The University of Michigan. Filee population sizes would be (approximately):

Wayne County	N = 400
Oakland County	N = 300 - 350
Washtenaw County	N = 200 - 250

b. Collect available descriptive information about each filee from available public records of the intent to divorce, and initiate preparation of subject files by county. The Wayne County data files will be prepared by the Marital Health Study.

c. Secure the driver record (with complete and current data) for each filee six to eight months subsequent to the dissolution of each marriage.

- d. Merge Wayne County subjects' driver record data with survey data on each filee collected by the Marital Health Study.
- e. Conduct correlational and multivariate analyses of crash, violation, and survey data for Wayne County filees.
- f. Conduct time-series analyses of crash and violation histories vis-a-vis acute episodic stress during the divorce process, for Wayne County filees.
- g. Formulate and test hypotheses relating the time periods most proximal to the dissolution of marriage to increased frequency of crashes, violations, alcohol-related crashes, and alcohol-related violations.

### 3.2 WORK STATEMENT DISCUSSION

The preceding work statement summarizes the research work we recommend be undertaken in Phase II. Tasks I-III are seen as a minimum research effort needed to answer some fundamental research questions regarding the incidence of A/R crashees among the general driving population and about the similarities and differences between A/R crashees and A/R convictees.

Tasks IV-VI deal with the collection and analysis of driving records of target groups believed to be at high risk to A/R crashes. To those given could be added a group of

Drunk & Disorderly convictees, shown in Section 2.2 to have a six-and-one-half year incidence to an A/R crash of about 0.441. On the assumption that the majority of the D & D convictees are males, the risk factor for this group can be estimated at  $0.441/0.035 = 12.6$ . This is certainly an acceptably high risk factor for the group to warrant further attention, but it has not been included at the present time for two reasons. First, there is a need to limit the scope of work proposed to something that is manageable. Second, no new and innovative countermeasures have surfaced for dealing with a D & D population at high risk to an A/R crash. The two reasons together have led to the omission of this group at the present time, but it could, of course, be added subsequently.

All study groups would be drawn from within the State of Michigan. Michigan is not claimed to be a superior study site over several others that could be named, but neither does it lack the attributes needed. As noted earlier, the investigation, reporting, and file maintenance of crashes in general, and A/R crashes in particular, by the state and local police agencies is satisfactory. Furthermore, The Michigan Department of State receives pertinent crash data, including accident severity and alcohol involvement, on each crash processed by the Department of State Police, and transcribes the data onto the driving records of Michigan drivers. HSRI has for many years been able to retrieve driving records on magnetic tape on any number of drivers for subsequent re-formatting and analysis.

These capabilities on the parts of all agencies concerned are central to the proposed research.

The proposed period of performance is fourteen months, from January 1, 1975, to February 29, 1976. Cost data are being supplied under separate cover.

### 3.2.1 Task I: Analysis of Random Sample of Michigan Drivers

This task is of central concern in the proposed research program. The objective is to establish a baseline of data regarding the incidence of drivers-of-record in A/R crashes. As noted in Section 2, some data on this subject do exist, but they are far too sparse to serve the required purposes. In particular the long-term incidence--say, up to seven years--is not known acceptably. Without this information there is no common base population from which to compute relative risk to A/R crashes, and comparisons among high-risk groups are hampered.

HSRI is currently negotiating with the Michigan Department of State to obtain a one-percent (1%) random sample of Michigan drivers. These data are expected to be in hand during the first quarter of FY-75, and the proposed analytical work could commence during the second quarter. The base costs of obtaining the random sample and building the data into an HSRI analytic file will probably be absorbed by the Department of State, judging from past experience. The costs of building the data into HSRI analytic files would be shared, and the project-specific analyses would be supported under the proposed research program.

### 3.2.2 Task II: Analysis of A/R Crashees

The material presented in Sections 2.2 and 2.3 raises a number of questions about the probability of experiencing a second A/R crash, given the occurrence of the first one. Resolution of this issue is considered important because of the countermeasure implications.

If A/R crashees are repeaters, then this suggests a well-defined target group worthy of special countermeasure attention. The data in Section 2.2 showed that, for a sample of DWI and D & D arrestees, 797 drivers experienced 1,037 A/R crashes in six-and-one-half years. Unfortunately, the distribution of the crashes by driver is not known. Nonetheless, the data show either that 797 drivers had one A/R crash and 240 drivers had two A/R crashes or that 797 drivers had one A/R crash and something less than 240 drivers had two or more A/R crashes. If the first is true, then we can conclude that the six-and-one-half year incidence to a second A/R crash, given the occurrence of the first, is  $240/797 = 0.301$ . If the second proposition is true, then the incidence of an even smaller group of drivers having a second A/R crash is even greater than 0.301. In either case, on the assumption that the samples from which the above inferences were drawn are representative and not pathologic, an important target group for A/R countermeasures would have been identified. The purpose of this task, then, is to explore fully the recidivism of A/R crashees.

Although it might seem reasonable to address this issue on the basis of the data obtained on the random sample of drivers in Task I above, such a procedure is not adequate. The incidence of A/R crashees having one A/R crash is so low--on the order of one percent (1%) per year--that the incidence of drivers having two or more A/R crashes is probably on the order of 0.01%. Even with an original sample of 55,000-60,000 drivers, we might find only five or six drivers per year with multiple A/R crashes on their records, clearly too small a number of drivers for in-depth analysis and statistical inferences.

Therefore we will attempt, in cooperation with the Department of State, to obtain a census of all Michigan drivers having at least one A/R event on their driving record. An A/R event is defined to include an A/R crash, an arrest and conviction for Driving Under the Influence of Liquor (DUIL), and an arrest and conviction for the lesser included offense of Driving While Visibly Impaired (DWVI). These data will be used both for the present task and for the next task. There is no question regarding the technical feasibility of this approach, and preliminary discussions with officials of the Department of State suggest that it is administratively feasible as well.

### 3.2.3 Task III: Analysis of Driving Records of DWI Drivers

The contract required the inclusion, as one of the study groups, of drivers arrested for DWI in an ASAP community.

Preliminary data for the Washtenaw ASAP DWI (including both DUII and DWVI) drivers were given in Section 2.2. Those data show a six-and-one-half year incidence of A/R crashes of 0.411, equivalent to a risk factor of about 12.

This demonstrated high risk to A/R crashes of a group of DWI drivers in Washtenaw County strongly argues that they will continue to be of concern to the traffic safety community. We believe, however, that the analysis should be extended to cover other DWI drivers in Michigan so that findings are not regionally biased. Further, the analysis of the A/R crashees (Task II above) complements the analysis of the DWI drivers, both logically and procedurally, and it is recommended that both be undertaken concurrently in the same jurisdiction.

#### 3.2.4 Task IV: Analysis of Driving Records of Blue-Collar Workers

The data throughout Section 2 consistently show that blue-collar workers are over-represented in A/R crashes among various populations of crash-involved drivers. The same data suggest, therefore, that blue-collar workers have elevated risks to A/R crashes with respect to the average driver.

The latter point cannot be established by sampling crash populations, however. It is necessary to sample the population of interest, blue-collar workers in this case, and determine the crash experience rather than to sample a population of crashees and determine the occupational status.



The purpose of this task is to begin a systematic evaluation of the risk factors of blue-collar workers generally, and of young, male, blue-collar workers with high rates of absenteeism specifically. "Young," "male," and "blue-collar" are all stratification criteria previously shown to be associated with A/R crashes on the age, sex, and occupational status variables. "With high rates of absenteeism" has been added as an additional stratification criterion because absenteeism is an indication of behavior problems and is one of the means by which early drinking problems are spotted in the labor force. Applying the four criteria simultaneously should define a target group with a high risk factor.

The purpose of this task is to confirm or refute that this group is at high risk to A/R crashes. In the meantime it is assumed that it is a high-risk group worthy of countermeasure attention. We have not been successful in Phase I in identifying any really new or innovative countermeasures to apply to the blue-collar group, or to any other high-risk group. Fortunately, however, there has been considerable success in recent years in dealing with problem drinkers through company-based rehabilitation programs, and possibly cost-effective countermeasures could be piggy-backed onto on-going rehabilitation programs.

HSRI has not yet obtained the necessary and extensive cooperation of a large industrial firm that will be needed to carry out the required analytic investigation. And of course we have not investigated the legal or ethical issues inherent

in injecting traffic safety considerations into an employee-employer relationship from a research perspective, much less a countermeasure perspective. However, contacts had been established earlier with the Medical Director of a firm with adequate numbers of blue-collar workers, and we are prepared to follow up with the medical and personnel departments of this firm to determine whether the proposed research is feasible.

### 3.2.5 Analysis of Driving Records of Assigned-Risk Insureds

In addition to the groups discussed earlier, we are also recommending the systematic study of drivers in the assigned risk insurance plans operated under the authority of insurance commissions in the individual states. DOT, in its Automobile Insurance and Compensation Study, analyzed many aspects of the plans, including the driving performance of assigned-risk insureds, but the results do not lend themselves to specification of risk factors to A/R crashes. The results do, however, suggest that subsets of the group, if not the whole group, will subsequently be found to contain many high-risk drivers. The following excerpts from various publications from the parent study are offered in support of this recommendation.

In 1967 there were 2.7 million vehicles insured through the assigned-risk mechanism, representing 2.8% of all registered vehicles and 3.3% of all insured vehicles. Males comprised over 70% of the insured in each of the several states that were studied. Driving under the influence of alcohol or drugs was

found to be the third most common offense on the driving records of the insureds, and the Ohio plan had the largest proportion of DUIs among its applicants, 36.4%. Insureds generally were found, as well, to have poorer driving records as reflected by the number of other violations and recorded accidents. Claims were more numerous and costly for assigned-risk drivers than for others. Young drivers were more common, as were occupations from the lower part of the socio-economic scale. In short, the assigned-risk insureds matched the crash-involved populations of Section 2 on a number of variables that identify A/R crashees.

The assigned-risk insureds would seem to offer possibilities from a countermeasure perspective as well. The insurers claim that they lose money on the assigned-risk plan because of numerous and costly claims, and they should welcome any research and operational efforts to improve the driving performance of the insureds. The insureds, on the other hand pay insurance premium surcharges that can range up to several hundred dollars per year, and a countermeasure approach based primarily on economic factors might prove attractive.

The proposed research would probably require the approval of the State Insurance Commissioner, and it would certainly require extensive cooperation from an underwriting company that handles a significant percentage of Michigan's assigned-risk drivers. Neither of these has been obtained to date, and we cannot guarantee that the research is feasible. This issue would

be resolved early in the research program if there is interest on the part of the Government.

### 3.2.6 Task VI: Analysis of Marital Stress and Alcohol-Related Crashes

Proposed herein is a quasi-experimental analysis of the effect of the process of divorce on alcohol-related crash involvements among adults filing for divorce in three Southeastern Michigan counties. HSRI is fortunate to have established a relationship with a currently active study of marital disruption and, therefore, the present proposal incorporates the anticipated survey data of that study in addition to official driver records from the Michigan Secretary of State.

Several investigations of stress, alcoholism, and crash involvement have identified marital problems as being a common denominator among drinking drivers involved in fatal or other serious traffic accidents. Among others, Evenson<sup>1</sup> isolated marital disharmony as being generally associated with problem drinking and alcoholism. Kephart<sup>2</sup> related drinking and marital disruption in a study of 1,434 divorces in Philadelphia between 1937 and 1950. He found that excessive drinking was alleged in more than twenty percent (20%) of the cases and was listed as a

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<sup>1</sup>Evenson, R. C., et al. "Factors in the Description and Grouping of Alcoholics." American Journal of Psychiatry, 130:1, January, 1973. pp. 49-54.

<sup>2</sup>Kephart, W. M. "Drinking and Marital Disruption: a Research Note." Quarterly Journal of Studies on Alcohol, 15, March, 1954. pp. 63-73.

complaint more frequently than any other single factor except desertion and other legal grounds for divorce. The charge of excessive drinking was listed more times than cruelty, adultery, bigamy, fraud, and sexual complaints combined.

Borkenstein<sup>1</sup> and Filkins<sup>2</sup> in separate investigations identified divorced and separated persons as being over-involved in alcohol-related traffic accidents. Brown<sup>3</sup> reported that in a population of fatal driver involvements the operators were subjected to multiple stresses and serious personal problems, and had often been drinking excessively at the time of the crash. Selzer and associates<sup>4</sup> have provided

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<sup>1</sup>Borkenstein, et al. The Role of the Drinking Driver in Traffic Accidents, Department of Police Administration, Indiana University, Bloomington, February, 1964.

<sup>2</sup>Filkins, L. D., et al., Alcohol Abuse and Traffic Safety: A Study of Fatalities, DWI Offenders, Alcoholics, and Court-Related Treatment Approaches, Final Report, Contract FH-11-6555 and FH-11-7129, Highway Safety Research Institute, The University of Michigan, June, 1970.

<sup>3</sup>Brown, S. L., et al., Alcohol Safety Study "Drivers Who Die," Final Report, Baylor University College of Medicine, 1968.

<sup>4</sup>Selzer, M. L., Rogers, J. E. and Kern, S., "Fatal Accidents: The Role of Psychopathology, Social Stress and Acute Disturbance," American Journal of Psychiatry, Vol. 124, No. 8, February, 1968, pp. 46-54.

Brenner, B. and Selzer, M. L., "Risk of Causing a Fatal Accident Associated with Alcoholism, Psychopathology, and Stress: Further Analysis of Previous Data," Behavioral Science, Vol. 14, No. 6, November, 1969, pp. 490-495.

Selzer, M. L. and Vinokur, A., "Life Events, Subjective Stress, and Traffic Accidents," American Journal of Psychiatry, Vol. 131, No. 8, August, 1974, pp. 903-906.

Selzer, M. L. and Vinokur, A., Detecting the High Risk Driver: The Development of a Risk Questionnaire, Final Report, Report No. DOT-HS-801-099, Highway Safety Research Institute, The University of Michigan, Ann Arbor, January, 1974.

documentation regarding the interrelationships of stress, problems with alcohol, and problems with driving. Waller and Flowers<sup>1</sup> stated that individuals who were single, divorced, or separated had higher traffic offense rates during license suspension than did those who were married or widowed.

In one of the few studies specifically dealing with the effects of divorce on driving performance, McMurray<sup>2</sup> related the emotional stress of the divorce process to impaired driving performance, higher violation rates, and higher accident rates for both men and women during the year of their divorce proceedings. This study demonstrated the effect on driving behavior of the act of filing for divorce, as a stressful event. The McMurray study took place in Washington State and incorporated into the analysis data covering seven years prior to and the year of the divorce proceedings for 410 persons filing for divorce.

HSRI proposes to replicate the design and intent of the McMurray study in three counties in Southeastern Michigan: Wayne, Washtenaw, and Oakland Counties. Selection of these counties was based on previous HSRI experience and research in

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<sup>1</sup>Waller, J. A. and Flowers, L. Previous Police Contacts, and Recidivism among Drivers with Arrests for Driving while Under the Influence of Alcohol in Vermont--Baseline Data. CRASH Report V-1, August, 1972, Waterbury, Vermont.

<sup>2</sup>McMurray, L. "Emotional Stress and Driving Performance: The Effect of Divorce." Behavioral Research in Highway Safety, 1, Summer, 1970. pp. 100-114.

these populations and the availability of a major concurrent investigation of persons filing for divorce in Wayne County. The Program for Urban Health Research, also at The University of Michigan, is conducting a study of marital health in Wayne County.

The Marital Health Study investigates the impact of marital separation and divorce on physical and mental health. The sample consists of over 400 men and women in the Detroit area who have contacted the Wayne County Circuit Court Marriage Counseling Service, either as a result of filing for divorce or because of serious marital problems. The subjects are interviewed at the initial contact with the Marriage Counseling Service and four months later. The sample is restricted to people who have at least one child under the age of eighteen. About one half of the interviews are with husband and wife of the same couple. The sample is about forty percent (40%) black and sixty percent (60%) white and represents all economic strata.

The major focus of this study is on the mediating effects of coping on the relationship between marital stress and health. The health outcomes include blood pressure, major health problems, drinking and drug-taking patterns, health habits and more common symptoms of illness, as well as measures of mental health and of mood such as depression, anxiety, and general psychological well-being. Coping is operationalized in a number of ways: handling anger and guilt; involvement in a network of

supportive social relationships; setting and reaching realistic goals in relationships with people of the opposite sex, with one's children, and in terms of work and career. Data are also collected on driving habits and exposure; experiences with other recent stressful events; the use and effectiveness of professional services from counselors, lawyers, clergy, etc.; socio-locus of control and a variety of attitudinal measures.

The particular strong points of the Marital Health Study are its focus on respondents in the midst of a stressful life change rather than ex post facto analysis of such an event, its relatively large and socioeconomically diverse sample, the panel design, and the multidisciplinary approach in collecting a variety of types of data.

In cooperation with the Marital Health Study, HSRI proposes to secure the driver records for respondents among the Wayne County respondents and perform analyses of traffic offenses and accidents concurrent with the divorce-related stressful period. Primary attention will be given to alcohol-related incidents noted on the driver records.

To expand the data base for broader inferences and more reliability, HSRI proposes to identify persons filing for divorce in Washtenaw and Oakland Counties (also in Southeastern Michigan) and to secure the driver records of these persons from the Michigan Secretary of State. Analyses of the effect of the divorce process in terms of accident and violation occurrences will be identical for all three populations of divorce files.



Inferences that appear to be stable from the analyses of the Wayne County survey responses and driving records will be made to the Oakland and Washtenaw County populations.

A final total of approximately 1,000 driver records will be secured from the Secretary of State and subjected to a variety of statistical analyses. To identify the differences between divorce-filee driving performances and other drivers, comparisons will be made against identical analyses of a one percent (1%) random sample of Michigan drivers (proposed elsewhere in this report).

There are a variety of potential implications of the proposed study of the effect of divorce on alcohol-related crash involvement. The act of filing for divorce is a public one and, therefore, provides an unobstrusive means of identifying a target group for alcohol-highway safety countermeasures, should the proposed investigation support a need for such action. Because filees for divorce are often participating in counseling services, the introduction of traffic-safety content in that counseling would provide the opportunity to create an unanticipated cognitive awareness of elevated risk in the divorcing individual. Divorce counseling services are established and operational, and an alcohol-countermeasure activity can easily be added to those services.



## APPENDIX A

### LITERATURE REVIEW

#### A1. INTRODUCTION

The concept of target groups in highway safety is a basic element in analyses of the epidemiology of accidents, including traffic accidents. One underlying assumption in the search for target groups to which countermeasures might be applied is that there is a causal chain of events leading to a crash. In other words, accidents are not assumed to simply "happen," but are caused by the intentional or unintentional behaviors of people. If this assumption were incorrect, then there would be no operational target groups, because accidents would be entirely random, unpredictable phenomena. We believe that alcohol-related crashes, as a specific subset of all traffic incidents, are predictable on the basis of interactive and complex combinations of factors. Our review of the literature has demonstrated few unanticipated findings, but has strengthened our conviction that the eventual predictability of alcohol-related accidents on the road will be a function of research brought up to date by future investigations of the precrash behavioral determinants of crash causation.

In 1961 McFarland and Moore (1) summarized an epidemiology of accidents. The basic concepts detailed by these authors related the field of medical epidemiology to traffic safety and concluded with a "host" orientation that has since been termed social or behavioral epidemiology. Dealing with traffic accidents, McFarland and Moore surveyed the range of theories of

accident causation. Three basic levels of causal explanation emerged: (1) Unusual Individual Susceptibility, (2) Personal and Social Maladjustments, (3) Temporary Factors Influencing Driving Performance. The first explanation is best exemplified by the various theories of "accident proneness," a concept that McFarland and Moore challenged on the basis of inconsistent and unconvincing research. The second concept was treated as having significantly more value than the psychiatric "proneness" theories. Several objective studies were cited as having demonstrated that persons who have been involved with one social agency (the police, a venereal disease clinic, a juvenile court, etc.), or involved in an alcohol-related highway accident, are quite likely to have been involved with another social agency. Thus, it seems that a small proportion of the human population repeatedly appears in the social statistics on which these studies are based. There is seductive appeal to the idea that a designated target group for one social problem is also a suitable target for one or more other problem-oriented countermeasures. The validity of the data, however, must be carefully assessed, in that social statistics relating to welfare, disease, accidents, and driving violations are subject to known and predictable biases. In short, the concept of a problem-producing minority in the population could be a self-fulfilling prophecy generated by interwoven and consistently biased data. There are certain findings in this area that, on the basis of tested external validity and generalizability, can be taken as social facts. These findings, which have been reviewed in depth, in-

clude the factors of youth, socioeconomic status, and driving-exposure time. These factors, however, are quite inadequate in terms of specificity vis a vis target-group identification.

The third area that has received theoretical and practical attention is the area of temporary factors influencing performance. This includes such topics as fatigue, physical defects, illnesses, drugs and medications, and temporary emotional states. That last factor is seen to interact with drinking and lead to temporary impairment and decrements in driving performance. McFarland and Moore (1) state:

Some accidents on the highway have been traced to pre-occupation with anxieties, or to carrying over emotional states into the manner of driving; but the usual investigation of accidents does not include evaluation of such factors... It is well known that when people are emotionally upset or preoccupied some disorganization of behavior is likely to occur. Under such circumstances, one may misinterpret the meaning of a situation or ignore important stimuli and make inappropriate responses. (p. 30)

That quotation raises two important points. First, it is suspected (though often from less than satisfactory evidence) that under conditions of anxiety and stress, some persons are more likely to undertake episodic drinking, and consequently exhibit drinking and driving patterns, that are hypothesized to increase their likelihood of being crash-involved. Secondly, although this quotation was taken from a 1961 source, it remains true that accident investigations rarely attend to temporary emotional or behavioral factors of the involved driver

(or dwell on other variables of potential importance). Consequently, the role of such factors, in combination with other factors, in causation of alcohol-related crashes remains unclear.

The following literature review is not intended to document the state of the art completely, but to exemplify the bases on which key decisions in the present study were made. The reviewed literature is presented according to the focus of research interest and the type and scope of the published information being described. For each variable category a methodological overview precedes a review of the critical studies and a summary of findings, facts, and issues raised by the research. The literature review concludes with a summary and a statement of the implications of the literature regarding our current ability to identify target groups in the driving population.

Before proceeding to the literature review proper, it is important to define the limits and purposes of the review. This review is not a comprehensive "state of the art" statement on the drinking driver, nor is it intended to cover the variety and magnitude of the available literature in definite detail. On the other hand, this literature review is intended to provide sufficient, representative, multi-disciplinary evidence to explain the directions taken in the developmental and empirical components of the study. Others (2,3) have provided comprehensive, general literature reviews. It was not the purpose of the present review to dup-

licate those efforts. This literature review was based on the need to determine the feasibility of identifying suitable target groups for alcohol-highway safety countermeasures. To the extent possible, the literature surveyed was limited to post-1969 publications and often to much more recent material. The literature review was oriented toward specific independent variables that have been researched to a degree sufficient for confidence and generalizability. Such variables include biographical, demographic, socio-economic, and certain situational measures. Whenever possible, existing literature reviews were searched to provide more efficient coverage of the field. This was always supported by examinations of primary sources to offset any potential biases introduced in secondary sources.

This literature review had a specific purpose based on the requirements of theoretically and practically valid countermeasures for target groups in the epidemiologic tradition. McGuire (4) identified such requirements as well as anyone. His criteria follow:

Target groups should be based on an individual variable or a combination of predictor variables that meet the following criteria:

- (1) It must be easy to obtain.
- (2) It must be highly reliable (for example, sex and age are very reliable, while a psychological test score may vary widely).
- (3) It must be a 'true' predictor--that is, capable of being gathered before the fact. Mileage, for example, is by definition an after-the-fact predictor.\* Pre-

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\*While true mileage is post-facto, estimated mileage is an appropriate "before-the-fact predictor."

ferably, this variable must be capable of being gathered retroactively and still retain its 'true' predictor label. For example, age and sex would qualify, since they may be accurately measured retroactively.

- (4) It must not be parochial--that is, peculiar to one region of the country, or peculiar to only a small subgroup of drivers.
- (5) It must not be controversial, politically sensitive, or objected to by subjects on grounds of being too personal, an invasion of privacy, etc. (pp. 104-105)

Thus, the present literature review sought to determine whether the current level of knowledge about the accident-involved drinking driver was adequate to justify the definition of target groups based on predictor(s) meeting the above criteria.

## A2. AGE AND YOUTH

The analysis of age and youth as predictors of alcohol-related crashes represents one of the most universal of all variable categories in the field. This is, of course, true of most social and epidemiological research. Joscelyn and co-workers (2) concluded in their review of the literature that, with conflicting findings of studies of fatalities, roadside surveys, interview and driving records, convictions and arrests, the basic and solitary conclusion was that problem-drinking drivers were under the age of 45. These authors, however, did not review numerous publications available to them at the time of their review, nor did they have available to them the findings of a large volume of literature that has since been generated.



The current research findings reviewed showed fairly clearly that young drivers are significantly more often involved than older drivers in crashes, fatal and injury-producing crashes, and alcohol-related crashes. Specifically, drivers under age 30 (particularly between 15 and 24) are more often crash-involved than other age groups.

Some efforts have been made to explain away this over-involvement of young drivers on the basis of exposure (5). However, the possibility of explaining away a causal relationship with one source of crash causation over another does not "explain away" the problem. Taken as a group, young drivers have been substantially shown to be of singular importance as a subset of the total driving population with unusually high probabilities of alcohol-related crash involvement.

A study of fatal case histories in Wayne County, Michigan, by Filkins, et al. (6) showed that 16- to 25-year-old drivers had a higher proportion of driver fatalities than their proportion of the total driver population. Goldstein (7) summarized the evidence supporting the thesis that youthful drivers are a special highway safety concern, although his review did not address the role of drinking. Harrington (8), in a longitudinal study of young California drivers, determined that the high rates of accident involvement decreased somewhat during the first four years of driving experience. However, even after four years of experience, the rates of accident involvement were higher than for adults.

On the premise that young drivers are an important research topic, Pelz, Schuman, and co-workers (9-13) conducted a series of studies. Those investigations, while not centrally focused on the interaction of drinking and driving, indicate that there might be certain characteristics of being young that discriminate between young and old drivers in terms of accident liabilities. The Pelz and Schuman studies determined that young drivers, especially males, drive more for emotional or recreational purposes and have higher rates of exposure than older drivers.

Since the advent of the Alcohol Safety Action Programs, the early roadside survey research findings (14) have been generalized to numerous other populations and places. From these studies it is consistently found that young drivers, and young males in particular, are most likely to be driving with elevated blood alcohol concentrations (15-18).

Douglass (19), O'Day (20, 21), and Carlson (16), in independent analyses of state accident data covering seven states for the time period from 1965 to 1973, have consistently indicated that reported alcohol-involved crashes, single-vehicle driver involvements with a male driver, and alcohol-related fatal crashes all exhibit maximum age-specific frequencies within the 18- to 24-year-old age range. Studies of the problem in Ontario and other jurisdictions in the United States corroborate the Michigan findings (22, 23).

The literature on drinking patterns and practices indicates that with few exceptions young people begin to drink at

approximately the same time that they learn to drive (24, 25). Several investigations have contended that a maturation process involving the "learning to drink" and "learning to drive" behaviors is a factor responsible for creating the over-involvement of young drivers in alcohol-related crashes (20, 26). Douglass, et al. (27) found that in seven states--Michigan, New York, Vermont, Maine, Louisiana, Texas, and Pennsylvania--maximum age-specific alcohol-related crash involvement for the 1968 to 1973 period was consistently predicted by the minimum legal drinking age or legal beverage alcohol availability (socio-cultural or geographic). When the legal drinking age was lowered, the maximum age-specific alcohol-related crash involvement changed accordingly.

Rosenberg, et al. (28) in a study of alcohol, age, and fatal traffic accidents, stated that blood alcohol concentrations were found to be higher among drivers under age 30 and also in one-car rather than two-car accidents, in nighttime rather than daytime accidents, and in weekend rather than weekday accidents. Peak occurrence of single-car crashes was found at a younger age than the peak blood alcohol concentration, suggesting to the authors that age interacts with drinking in accident causation (29).

These and many other investigations (30-34) have determined that age is of critical concern in the prediction of target groups for alcohol-highway safety countermeasures. Age, however, is far too imprecise a parameter for purposes of prediction.

The extent to which the predictability of alcohol-related crashes is now an operational practicality will be revealed in the following reviews of other variables.

### A3. SEX

As Joscelyn, et al. (2) correctly noted in their review of the literature:

No other variable's importance in the characterization of the problem drinking driver has been as conclusively demonstrated as has that of the sex of the individual. The populations in every study are predominately male, and the incidence rate of problem drinking drivers among males is greater than among females. (p 12)

McGuire (4) in an analysis of accident-producing behavior stated:

Two variables in particular stood out--age and sex. So important was this relationship found to be, that we no longer gather and analyze accident-related data without separating according to sex and age whenever possible. So far, we have discovered (or rediscovered) that there are few or no psychological variables in the real world which do not differ among age and sex groups. Accident rates are different, violation rates are different, mileage, night driving, rural driving, and many of the correlates thereof are different. In fact, strange as it may seem, I have come to the conclusion that sex differences are one of the most neglected areas of research in all of the behavioral sciences. (p. 105)

These conclusions and insights are valid for alcohol-related crashes, arrests, and convictions. Most of the documentation supporting the importance of age as a predictor also support the

role of sex. Although generalizations into the future must be made with adequate consideration for social changes, the male drinking driver appears to define the primary population at risk of an alcohol-related crash. In combination with the age variable, the prediction of one target group can now be somewhat defined as young males--a definition still far too general for an operational target group.

#### A4. OTHER DEMOGRAPHIC VARIABLES

Of all the variables associated with alcohol and driving, demographic variables (age, sex, marital status, race) are the most routinely collected, the most consistently reported on accident forms, driving records, license applications, work records, etc., and the most reliable to use to define subgroups of the general population. We have discussed age and sex in relation to the alcohol crash population. In this section we will discuss marital status and race, and their association with alcohol-related crash populations.

Demographic variables are generally used in two ways in the study of accident occurrence in populations:

(1) The demographic variables are used as definers of the population to be studied, such as young drivers (see previous section) or divorced drivers.

(2) Demographic variables are also used as predictive variables to delimit a population of over-involved drivers, when the study population is chosen at random.

A difficulty encountered in the literature is the variety of methods of measuring marital status. While some studies were found to measure all levels of marital status (6, 14, 35), others tend to dichotomize the variable into married (including widowed) or single (including divorced) (36-38). This difference in measurement or operational definition makes it difficult to compare the interactive effects of such variables as age on marital status.

In an early study of the at-risk drinking-driving population it was found that while separated and divorced drivers made up a very small proportion of the driving population, they comprised a significant proportion of the drinking-driving population (14). In analyses of fatal drinking and non-drinking drivers, several authors have shown that separated and divorced drivers comprise a much higher percentage of the fatal accident population than of the general driving population (6, 35, 38, 39). In analyses of drinking driver populations as defined by DWI arrests, it has also been demonstrated that the divorced and separated driver is overrepresented (6, 39). A case-history study of fatal-accident drivers examined the causes of stress in drivers and found that a significant number of drivers were adversely affected by family problems, as reflected by the number of divorced or separated in the population (35).

Race, when included in the study, is usually divided into white and non-white categories. This variable is not included in a number of studies due to the controversial issue of using this variable. One of the prerequisites for the use of any

variable in accident research is that the variable not be one that would cause concern in the community if used to define groups (4). Some studies have measured this variable and have found non-white groups to be overrepresented in accidents (6) and drunk driving populations (39).

When marital status is included in more sophisticated analytic techniques, conflicting results are reported. In a study to predict negligent operators it was found that marital status was significantly associated with the negligent operator classification (this study used a dichotomous classification) (37). In a comparative study of a DWI population and a fatal drinking-driver population, marital status was not a factor in predicting alcohol involvement (36).

Marital status and race, as variables to define subgroups of over-involved accident drivers, appear to have some value, as reported by the literature. Race as a variable has inherent problems which tend to discourage its use in the studies reviewed. In areas of the country where a significant proportion of the population is non-white, the issue of its use must rest with the investigator. Marital status, however, has been consistently shown to be significantly related to drinking, both in the population at risk and in subgroups of drinking and accident-involved drivers.

#### A5. SOCIO-ECONOMIC VARIABLES

The socio-economic classification of drivers has taken many forms in the literature. The variables included in this category

range from income level and type of job to social class, and include such behavioral indices as the number of jobs held in a previous time period. Also, generally included as socio-economic indicators are educational background and parental occupation and education. Clearly these variables all attempt to measure an orientation toward a specific social position. It would be expected that there would be a strong correlation between such variables as education and occupation.

An analysis of driving records of an alcoholic driving population indicated that semi-skilled and unskilled workers had fewer crashes, while skilled manual workers were over-represented among those with crashes on their driving record (6). Similar results were obtained when the relationship of occupation to DWI conviction was examined. However, it was found that unskilled workers tended to have more DWI convictions than skilled workers (39). Other studies have also indicated that lower occupational levels tend to be over-represented in problem-drinking, DWI, or crash populations (14, 30, 35, 38, 40, 41). The number of jobs held in a previous time period, a variable which includes behavioral and social-class aspects, has also been demonstrated to correlate with drunk driving and accidents (38, 42). Credit ratings were also examined as an indicator of driving behavior. A poor credit rating was also found to correlate with a poor accident and violation history (43). Educational level tends to parallel occupational-level results; the highest grade completed tends to be lower as



drunk-driving convictions or accident occurrence increase (4, 14, 30, 44). Parental occupation and education also appear to be related to accident occurrence, principally for younger drivers, where it was found that the higher the parental occupation and education level, the higher the accident rate (4).

As demonstrated by the literature, socio-economic indicators appear to be consistently related to alcohol and driving behavior. There is a tendency for lower social and economic levels to be over-represented in accident-involved driver populations.

#### A6. PREDICTION FROM VIOLATION AND CONVICTION DATA

Driving records, as compiled by states, and criminal records offer an attractive and easily accessible source of data for identifying high-risk drivers. Assuming that these public records have an acceptable level of accuracy and completeness for the type of violations or convictions to be used, two points must still be proven. First, it must be demonstrated that some types of convictions are significantly associated with accidents. Second, it must be demonstrated that a violation or sum of violations in one time period predicts accident occurrence in a subsequent time period. If it is a true assumption that public records are sufficiently accurate and complete and the two above criteria are met, it would then be possible to generate a predictive model based on past violations and/or convictions.

Few studies have used criminal records in an attempt to predict driving behavior, and none of the studies reviewed used alcohol-related accidents alone as a prediction criteria. While

one study developed a prediction model for drunk-driving arrests (44) and another used a population of alcoholics (45), most studies reviewed used reported crashes as the prediction criterion.

Two main approaches have been used to study the relationship between accidents and violations: (1) an analysis of driving records and, in some studies, criminal-record data for a given time period, comparing accident history and violation history of the same time period; or (2) a compilation of violation data for one time period and accident data for a second time period (usually a consecutive period). While it is much easier to collect data from one time period on both violations and accidents, the second method offers more insight into the actual predictive value of violation data and the effects of other variables.

The first method of analysis has been used by a number of investigators (39, 45, 46, 47). The attraction of this method is the ease of data collection, length of time necessary for data collection, and consistency of data in public records in one time period. It is fairly easy and less costly to collect the total driving record for a given period and analyze the violations for the period against accidents for the period. It is also easier to identify high-accident drivers at the end of a period than to try to follow a much larger sample of drivers over a period to find a few high-accident drivers for analysis. However, it has not been demonstrated that a truly

predictive model can be devised from concurrent accident and violation data.

Another method (4, 42, 48, 49) consisted of collecting the violation and accident history for time-period one ( $t_1$ ) and comparing it to the accident history in time-period two ( $t_2$ ). Some studies (4, 42) also administered primary data collection in the form of questionnaires or tests at the end of time-period one.

When violations were compared to accidents for the same time period, it was found that the total number of violations was the best predictor of accidents in some studies (45, 47), or there was a significant relationship between some selected types of violations and accidents (46). Another study found no significant relationships (39). Studies which have attempted to find predictive types of violations in one time period for accidents in a second have met with mixed results. A study of high-accident drivers in one year showed that a prediction for following years should be based on the total number of accidents in the first year, but that most drivers improve their driving in subsequent years (48). In a study of all drivers in one state, it was found that accidents in the first time period were the best predictors of accidents in the second period, but that most accidents occurring in any time period involve drivers with no accidents or violations in the previous period (49).

If other variables are entered into the analysis, the predictive strength of past driving violations is altered. It has been demonstrated that attitude scales combined with past

driving record increase the correlation of both with future accidents (42), that younger drivers have less-predictable driving records (49), and that inclusion of a larger number of variables reduces the amount of variance explained by past violation records (4, 39). The use of more advanced analytic techniques provides us with little more information. If all items of driving and criminal records are entered into analysis by type, it is found that some types of violations are more significant than others (39, 46) but more often the total number of convictions is the most significant predictor of accidents (42, 45, 47-49).

It was consistently found in these studies that accidents were much better predictors of accidents than were violations (46, 48, 49). While some studies indicated that high-accident drivers are characterized by a high violation rate (39, 48), it was found that most drivers involved in accidents had no accidents or violations in the past (49), or that most high-accident drivers in one time period were accident-free, or had a greatly reduced rate, in the following time period (48). One study which dealt primarily with DWI prediction found that many traffic and criminal offenses did correlate to a significant degree with drunk driving (39). Since it has been shown that accidents can, to some extent, predict accidents, and that violations are associated with drunk driving, these variables should be considered in any attempt to develop a prediction model based on available data sources.

A7. PREDICTION VIA PSYCHIATRIC, PERSONALITY, AND  
PSYCHOLOGICAL TESTING

Substantial efforts have been made by numerous investigators to correlate and predict accident-prone or high-risk drivers with personality indices and psychiatric or psychological measures. The evidence, however, fails to support the use of such devices for purposes of identifying target groups for countermeasure implementation.

Regarding the use of the McGuire Safe Driver Scale, the author states:

In prediction, we found that once a suitable number of biographical variables are considered, the use of personality test items are of very little significance, especially when sex and age are involved. As mentioned earlier, of additional importance is the fact that biographical variables are statistically more reliable (that is, each time the measure is taken the result, or "score," is likely to be the same), less controversial (many people resent and reject psychological testing), and much easier to gather. (4, pp. 115-116)

Other investigators have arrived at similar conclusions. Hanen (51) reported an insurance firm's experience in the use of an attitude-personality inventory for determination of auto insurance rates. Although the author defended the use of the instrument for a self-selection population of young, male applicants, there was no evidence that the validity of the predictions was tested in a normal driving population.

Kleinknealt (43) reviewed efforts regarding Washington State's Driver Improvement Interview as a prediction of problem drivers. The interview was based on an attitudinal personality-formatted questionnaire. It was concluded that the high failure rate of the thirty-minute interview to predict poor drivers negated the value of the procedure.

Kraus and co-workers (52) found that in a study of 205 drivers under age 21 in Ontario, certain psychological measures failed to discriminate between good and bad drivers. Self-ratings of degree of aggressiveness, irresponsibility, social conformity, and difficulty in tolerating frustration failed to show a statistically significant difference between a control group and an accident-involved group of young drivers.

Harano, et al. (30) sought to determine the predictability of traffic accidents by the use of biographic data and psychological tests. The investigators collected data on a sample of 950 drivers who had been driving for at least three years and who were under the age of 65.

Data included standard biographical and demographic measures plus a battery of psychological tests, which included:

- (1) Interview (with the exception of the driving record selection).
- (2) Vocabulary test.
- (3) Embedded Figure Test.
- (4) Gordon Personal Profile and Inventory.
- (5) Parent-Child Inventory.
- (6) Eye-Hand Coordination Task.

- (7) California Inventory of Driver Attitudes and Opinions (CIDA0).
- (8) Physical check list and vision test.
- (9) Reaction time measurements.
- (10) Simulator performance.
- (11) Interview (driving record portion only).
- (12) Rating of subject by experimenter. (p. 13)

Dependent variables and predictors of driving performance were taken from official driving records.

Multivariate analyses, including cluster analyses and multiple linear stepwise regression analyses, were performed on the full data set, which included the following components:

- (1) Biographical data.
- (2) Life-style variables (satisfaction indices, smoking and drinking habits, etc.).
- (3) Automobile description and driving-related activities
- (4) Attitudes.
- (5) Parental relationships.
- (6) Personality and cognitive tests.
- (7) Attitude and interest tests.
- (8) Criminal arrest record.
- (9) Perceptual-motor skills and physical checklist.
- (10) Mileage and convictions.
- (11) Simulator summary scores.
- (12) Cluster scores.
- (13) Simulator event scores and reaction-time standard deviations. (p. 15)

This study represents the most satisfactory attempt to predict accidents with a multi-dimensional set of predictor variables and indices. It was concluded that accidents could be predicted.

However, because the investigators combined accidents and traffic convictions into a single dependent variable criterion, the results cannot be generalized to the problem of predicting accidents independent of traffic convictions (p. 52). In addition, the unique contribution of non-biographical and demographic variables to the accident-conviction variance explained in the analyses, i.e., the psychological and attitudinal measures, was uniformly small when compared to the independent contributions of standard independent variables. It was only in combination with biographical variables that psychological tests were statistically predictive of problem drivers. In addition the use of, or accident-involvement-with, alcohol (except for minor attention to general drinking habits) was not included in the research. Therefore, the results are less than satisfactory regarding the prediction of alcohol-related accidents.

Lisansky (53), in a chapter directed to clinical research in alcoholism and the use of psychological tests, provided a final conclusion that psychological procedures were far from satisfactory. In her discussion the author stated:

Having once again reviewed the research reports of psychological test results of alcoholics, and having once again found its contribution so minimal, we find that there remain several issues to be raised.

If indeed the research reports involving psychological tests have failed to demonstrate the existence of "the alcoholic personality" or a single "type," do psychologists then withdraw all claim to the terrain of etiology? There is a position held by some that



addictive behavior can be explained in terms of availability of the addicting substance and/or group membership, the social milieu, and within these limits almost anyone qualifies as a potential alcoholic or addict. But the failure of psychologists and psychiatrists to demonstrate "the alcoholic personality" in no way negates the importance of personality factors as playing a major role in etiology. We have stopped looking for the vague, amorphous, ill-defined whole and started looking for the more specific, more precisely defined parts, i.e., for those personality factors which are necessary (although not sufficient) to explain the adoption of an addictive psychopathology.

Shotgun methods of studying "the alcoholic personality" have failed here as they have failed wherever applied....Psychological tests seem to have been over-used and over-extended generally but the unwise use of a tool only proves the user's lack of wisdom. It seems likely that psychological tests in research will find maximal usefulness in combination with other information-gathering techniques. Occasionally, a specific test may be used to answer a specific question.

Certainly it is true that the test literature has not yielded evidence for "the alcoholic personality," but it is also true that we cannot reject the idea that personality factors play a very significant role in determining who will become an alcoholic and who will not. The great study of alcoholism, a longitudinal, self-evaluating, flexible and comprehensive research plan, will need to include all the psychological and sociological variables we now think relevant and those we have yet to learn about. (42, pp. 11-13)

There have been few indicators in the present reading of the alcohol-highway safety literature that the state-of-the-art of predicting alcohol-related accidents with psychological tests is at all different from Lisansky's observations.

McFarland (1) p. 26, dispenses with the concept of "accident proneness" as being too general a term to be useful for epidemiologic utilization or for intervention-prevention programs. Campbell and Levine (54) similarly discounted the utility of accident proneness as a basis for screening out problem drivers. Although Shaw & Sickel (55, 56) have provided an impressive collection of research findings specifically dealing with the concept of accident proneness and highway safety, it is our conclusion that (1) most investigations cited were inadequate in terms of design or analysis, (2) results were non-generalizable to normal populations, (3) the international flavor of the collected research findings on accident proneness fails to provide sufficient specificity for any single population, as a whole, or precision for target group identification. It is our firm belief that, in agreement with Campbell, Levine, McFarland, and others, accident proneness is but a subset of the full range of psychological testing and prediction of problem drivers; these methods, by themselves, are inadequate for pre-crash identification of drivers at high risk of accident involvement and/or alcohol-related accident involvement.

A8. STRESS, DRINKING, AND DIVIDED ATTENTION;  
PREDICTORS OF THE PRECRASH PHASE

A number of investigators in recent years have focused on the precrash determinants of alcohol-related accidents. These investigators have proceeded on the basic premise that, while on occasion most adults drink and drive, only a minority become crash-involved. The precrash-phase research has sought to identify the processes that discriminate between crash-involved and non-crash-involved drinking drivers.

Several studies have determined that crash-involved drinking drivers were drinking greater quantities of alcohol prior to the crash and had higher BACs than other drinking drivers in the driving population (6, 14, 35). Precrash investigators have, in recent years, focused on the perplexing question of why the crash-involved drinking driver was drinking so much prior to the crash, and what other determinants of the crash can be identified.

Brown, et al. (35) in a study of fatalities, stated:

The victims-to-be on the highway seem to be shouldering a much greater burden of stresses than were the controls; 80% of the victims had serious problems at the time of their collision while only 12% of the controls were similarly afflicted. This gap was actually even greater, since many of the traffic victims had multiple stress, while the controls seldom had more than one significant worry.

The authors identified interpersonal and marital, financial, and vocational stresses as being paramount among the victims,

and a serious interpersonal conflict in the 24 hours immediately preceding the collision was experienced by 56% of the victims. Marital discord and the emotional and financial burdens subsequent to a marital dissolution were identified as a most common factor among the victims' "generally disorganized, chaotic life."

Causal, rather than correlational, relationships between stress, drinking problems, and crash involvement have never been adequately researched. Alcoholics and alcohol-related crash victims are frequently reported to have numerous social and personal problems. Resolution regarding the time-ordering of drinking-driving problems and others in the social-personal areas has not been forthcoming. However, the concomitance of stress and drinking-driving problems is generally accepted.

Selzer and associates (41, 57-59) have provided further evidence that stressful life events contribute to drinking problems, alcoholism and alcohol-related highway accidents. In a series of investigations of driving populations, psychiatric patients, alcoholics, and crash-involved drivers, the interwoven roles of stress, acute episodic drinking problems, and periodic levels of impaired driving performance have provided some insights into the causal determinants of crashes related to alcohol.

Closely associated with the research described above, on a theoretical level, are investigations of the role of driving as a divided-attention task that interacts with alcohol-

impairment in crash causation. Moskowitz, in Perrine (60), summarized recent findings in this area:

It was concluded that alcohol affects the ability to process appreciable quantities of information when these arrive from more than one source simultaneously, as is typical of the requirements for driving.

Specifically the author concluded that:

What is clear from all of these studies is that tasks measuring time for complex information-processing show a greater alcohol-induced performance decrement than simpler processing situations. Whether this is the result of interference with some processing of the potential range of stimuli and responses--as implied by an information theoretic view--or whether it is due to the number of central processes involved in the task, is of less immediate concern than the unanimous agreement that alcohol causes greater response impairment when the response requires complex information-processing than when only simple motor-reaction times are involved.

Voas (31) and Moskowitz (60) offered further evidence of the importance of viewing driving as a divided-attention task especially subject to performance decrement under the influence of alcohol.

The relationship between the literatures on stress and divided-attention performance is found when the cause of an individual's stress is viewed as an overwhelming focus of cognitive attention competing with the multiplicity of other stimuli while driving. If driving is normally a complex information-processing task, then the introduction of an acute

stressful problem further complicates the situation. If the stressful situation itself becomes the central focus of a drinking driver's attention (a cognitive requirement set), then the level of impairment affecting all multiple stimuli specific to the driving task will be exaggerated. Thus acute stress, interacting with alcohol, would be expected to greatly increase the likelihood of driving performance decrement and crash occurrence. This could be a discrimination between crash-involved and non-crash-involved drinking drivers. However, the definitive research remains to be performed.

McMurray (62) investigated the effect of divorce as an emotional, stressful state on driving performance. An analysis of the driving records of 410 persons involved in divorce proceedings indicated that all persons in the divorce-process sample had more accidents and violation citations than the average driver in the State of Washington over a seven-year period. Proximity in time to the year of divorce was related to the frequency of traffic incidents, and men experienced more incidents throughout the study period than women.

## APPENDIX A REFERENCES

1. McFarland, R. A. and Moore, R. C., "The Epidemiology of Accidents," Accident Prevention, ed. by M. N. Halsey, McGraw-Hill, 1961, pp. 17-45.
2. Joscelyn, K. B., Maickel, R. P. and Goldenbaum, D.M., The Drinking Driver: A Survey of the Literature (Court Procedures Survey; Reference Volume I,) Final Report, Report No. DOT-HS-800-608, Institute for Research in Public Safety, Indiana University, Bloomington, October, 1971.
3. Arthur D. Little, Inc., The State of the Art of Traffic Safety, for the Automobile Manufacturers Association, Inc., June, 1960, pp. 231-273.
4. McGuire, F. L., "The Understanding and Prediction of Accident-Producing Behavior," Highway Safety: Anatomy of a Problem, North Carolina Symposium on Highway Safety, Vol. I, Chapel Hill, Fall, 1969, pp. 101-124.
5. Zylman, R., "Age is More Important Than Alcohol in the Collision-Involvement of Young and Old Drivers," Journal of Traffic Safety Education, Vol. 20, No. 1, October, 1972, pp. 7-8, 34.
6. Filkins, L. D., et. al., Alcohol Abuse and Traffic Safety: A Study of Fatalities, DWI Offenders, Alcoholics, and Court-Related Treatment Approaches, Final Report, Contract FH-11-6555 and FH-11-7129, Highway Safety Research Institute, The University of Michigan, June, 1970.
7. Goldstein, L.G., "Youthful Drivers as a Special Safety Problem," The Young Driver: reckless or unprepared?, North Carolina Symposium on Highway Safety, Chapel Hill, Vol.5, Fall, 1971, pp. 37-93.
8. Harrington, D. M., The Young Driver Follow-Up Study: An Evaluation of the Role of Human Factors in the First Four Years of Driving, Final Report, No. 38, California Department of Motor Vehicles, September, 1971.
9. Schuman, S. H., Pelz, D. C., Ehrlich, N. J. and Selzer, M. L., "Young Male Drivers Impulse Expression, Accidents, and Violations," Journal of the American Medical Association, Vol. 200, July 1967, 1026-1030.
10. Pelz, D. C. and Schuman, S. H., "Dangerous Young Drivers," HSRI Research, Highway Safety Research Institute, The University of Michigan, Ann Arbor, No. 2, June 1968.

11. Pelz, D. C. and Schuman, S. H., Young Drivers: Road Behavior and Motivations, presented at the Third Traffic Accident Congress, New York City, May, 1969.
12. Pelz, D. C. and Schuman, S. H., Exposure Factors in Accidents and Violations of Young Drivers, Highway Safety Research Institute, The University of Michigan, Ann Arbor, 1971.
13. Pelz, D. C. and Schuman, S. H., Motivational Factors in Crashes and Violations of Young Drivers, Highway Safety Research Institute, The University of Michigan, Ann Arbor, 1971.
14. Borkenstein, et. al., The Role of the Drinking Driver in Traffic Accidents, Department of Police Administration, Indiana University, Bloomington, February, 1964.
15. Research Triangle Institute, Mecklenburg County Drinking/Driving Roadside Interview Survey, 1970, Project SU-582-4, Statistics Research Division, Research Triangle Park, January, 1971.
16. Carlson, W. L., "Alcohol Usage of the Nighttime Driver," Journal of Safety Research, Vol. 4, No. 1, March, 1972, pp. 12-25.
17. Clark, C. D., Compton, M. J., Douglass, R. L. and Filkins, L. D., "A Three Year Comparison of Alcohol Related Driving Behavior in Washtenaw County, Michigan," Hit Lab Reports, Highway Safety Research Institute, The University of Michigan, Vol. 4, No. 2, October, 1973.
18. Waller, J.A., Worden, J.K., and Maranville, I.W., Baseline Data for Public Education About Alcohol and Highway Safety in Vermont, CRASH Report I-1, Vermont Department of Mental Health, Waterbury, February, 1972.
19. Douglass, R. L. and Filkins, L. D., "Empirical Development of A Surrogate Measure of Alcohol Involvement in Official Accident Data," Hit Lab Reports, Highway Safety Research Institute, The University of Michigan, Vol. 4, No. 9, May, 1974, pp. 7-11.
20. O'Day, J., "Characteristics of Alcohol Involvement in Michigan Fatalities 1966-1969," Hit Lab Reports, Highway Safety Research Institute, The University of Michigan, October, 1970, pp. 4-8.
21. O'Day, J., "Drinking Involvement and Age of Young Drivers in Fatal Accidents," Hit Lab Reports, Highway Safety Research Institute, The University of Michigan, October, 1970, pp. 13-14.



22. Schmidt, W. and Kornaczewski, A., "The Effect of Lowering the Legal Drinking Age in Ontario on Alcohol-Related Motor Accidents," paper presented at the 6th International Conference on Alcohol, Drugs and Traffic Safety, Toronto, September, 1974.
23. Williams, A. F., et al., The Legal Minimum Drinking Age and Fatality in Motor Vehicle Accidents. Insurance Institute for Highway Safety, Washington, D. C., 1974.
24. Johnston, L., Drugs and American Youth, Report from the Youth in Transition Project, Institute for Social Research, The University of Michigan, Ann Arbor, 1973.
25. National Commission on Marihuana and Drug Abuse, Drug Use in America: Problem in Perspective, Second Report, U.S. Government Printing Office, Washington, D. C., March, 1973.
26. Pelz, D. C., McDole, T. L. and Schuman, S. H., Drinking-Driving Behavior of Young Men in Relation to Accidents, paper prepared for September, 1974 APA meetings, New Orleans, January, 1974.
27. Douglass, R. L., Filkins, L. D. and Clark, F. A., The Effect of Lower Legal Drinking Ages on Youth Crash Involvement, Final Report, DOT-HS-031-3-754, Highway Safety Research Institute, The University of Michigan, Ann Arbor, June, 1974.
28. Rosenberg, N., Laessig, R. H. and Rawlings, R. R., "Alcohol, Age and Fatal Traffic Accidents," Quarterly Journal of Studies in Alcoholism, Vol. 35, 1974, pp. 473-489.
29. Ingersoll, R. L., Trow, J. E. and Clarke, D. W., The High Risk Driver a Descriptive Study, Program on Alcohol & Drug Abuse, New Hampshire Division of Public Health, Concord, September, 1970.
30. Harano, R. M. McBride, R. S. and Peck, R. C., The Prediction of Accident Liability Through Biographical Data and Psychometric Tests, Final Report, Research and Statistics Section, Department of Motor Vehicles, California Division of Highways, Sacramento, March, 1973.
31. Voas, R. B., "Alcohol as an Underlying Factor in Behavior Leading to Fatal Highway Crashes," Proceedings of the First Annual Alcoholism Conference of the National Institute on Alcohol Abuse and Alcoholism, ed. by M. E. Chafetz, National Institute on Alcohol Abuse and Alcoholism, June, 1971, pp. 324-331.

32. Klein, D., "Adolescent Driving as Deviant Behavior," The Young Driver: reckless or unprepared?, North Carolina Symposium on Highway Safety, Chapel Hill, Vol. 5, Fall, 1971, pp. 3-19.
33. Schuster, D.H., "The Young Problem Driver," The Young Driver: reckless or unprepared?, North Carolina Symposium on Highway Safety, Chapel Hill, Vol.5, Fall, 1971, pp. 111-131.
34. Klein, D. and Waller, J. A., Causation, Culpability and Deterrence in Highway Crashes, Report of Automobile Insurance and Compensation Study, Department of Transportation, Washington, July, 1970.
35. Brown, S. L., et al., Alcohol Safety Study "Drivers Who Die," Final Report, Baylor University College of Medicine, 1968.
36. Pollack, S., et al., Drinking Driver and Traffic Safety Project, Annual Report, Public Systems Research Institute, University of Southern California, Los Angeles, July, 1970.
37. Levonian, E., "Prediction of Accidents and Convictions," Traffic Safety Research Review, Vol. II, 1967, pp. 75-79.
38. Perrine, M. W., Waller, J. A. and Harris, L. S., Alcohol and Highway Safety: Behavioral and Medical Aspects, Final Report, DOT-HS-800-599, Department of Psychology, University of Vermont, Burlington, September, 1971.
39. Pollack, S., et al., The Drinking Driver and Traffic Safety Project, Annual Report, Public Systems Research Institute, University of Southern California, Los Angeles, Vol. I., July, 1969.
40. Cahalan, D. and Room, R., Problem Drinking Among American Men Aged 21-59, presented at American Public Health Association Meeting, Minneapolis, October, 1971.
41. Selzer, M. L. and Vinokur, A., Detecting the High Risk Driver: The Development of a Risk Questionnaire, Final Report, Report No. DOT-HS-801-099, Highway Safety Research Institute, The University of Michigan, Ann Arbor, January, 1974.
42. Schuster, D. H., "Prediction of Follow-Up Driving Accidents and Violations," Traffic Safety Research Review, Vol. 12, No. 1, March, 1968, pp. 17-21.

43. Kleinknecht, R. A., An Analysis of Washington's Driver Improvement Interview: A Study In Prediction and Control of Problem Drivers, Report 017, Division of Research, Administrative Services, State of Washington, Department of Motor Vehicles, August, 1968.
44. Didenko, O. R., McEachern, A. W. and Berger, R. M., Drinking Driver and Traffic Safety Project, Final Report, DOT-HS-800-699, Public Systems Research Institute, University of Southern California, Los Angeles, Vol. I, May, 1972.
45. Clay, M. L., Which Drunks Shall We Dodge?, presented at the Twenty Third Annual Meeting, Alcohol and Drug Problems Association of North America, Atlanta, September, 1972.
46. Peck, R. C. and Coppin, R. S., "The Prediction of Accident Involvement Using Concurrent Driver Record Data," Traffic Safety Research Review, Vol. II, No. 2, June, 1967, pp. 34-41.
47. Carlson, W. L., "Identifying The Problem Driver From State Driving Records," HSRI Research, Highway Safety Research Institute, The University of Michigan, Ann Arbor, No. 1, May, 1968.
48. Goodson, J. E., Changing Characteristics of High Accident Drivers Over A Five Year Period, No. 29, Engineering Experiment Station, Purdue University, West Lafayette, September, 1972.
49. Stewart, J. R. and Campbell, B. J., The Statistical Association Between Past and Future Accidents and Violations, Highway Safety Research Center, University of North Carolina, Chapel Hill, December, 1972.
50. McGuire, F. L., A Study of Methodological and Psychosocial Variables in Accident Research, Public Health Service Bureau of Community Environmental Management, U.S. Department of Health, Education and Welfare, March, 1971.
51. Haner, C. F., "Prediction of Automobile Claims by Psychological Methods--A Case Study in Automobile Insurance," Journal of Risk and Insurance, March, 1968.
52. Kraus, A. S., Steele, R., Ghent, W. R. and Thompson, M. G., "Pre-Driving Identification of Young Drivers With a High Risk of Accidents," Journal of Safety Research, Vol. 2, No. 2, June, 1970, pp. 55-66.
53. Lisansky, E. S., "Clinical Research in Alcoholism and the Use of Psychological Tests: A Reevaluation," Alcoholism, Behavior Research, Therapeutic Approaches, ed. by Ruth Fox, Springer, New York, 1967.

54. Campbell, B. J. and Levine, D., Accident Proneness and Driver License Programs, presented at the International Conference on Driver Behavior, Zurich, October, 1973.
55. Shaw, L. and Sichel, H., Accident Proneness, Pergamon Press, Oxford, 1971.
56. Shaw, L., "The Practical Use of Projective Personality Tests As Accident Predictors," Traffic Safety Research Review, Vol. 9, No. 2, June, 1965, pp. 34-72.
57. Selzer, M. L., Rogers, J. E. and Kern, S., "Fatal Accidents: The Role of Psychopathology, Social Stress and Acute Disturbance," American Journal of Psychiatry, Vol. 124, No. 8, February, 1968, pp. 46-54.
58. Brenner, B. and Selzer, M. L., "Risk of Causing a Fatal Accident Associated with Alcoholism, Psychopathology, and Stress: Further Analysis of Previous Data," Behavioral Science, Vol. 14, No. 6, November, 1969, pp. 490-495.
59. Selzer, M. L. and Vinokur, A., "Life Events, Subjective Stress, and Traffic Accidents," American Journal of Psychiatry, Vol. 131, No. 8, August, 1974, pp. 903-906.
60. Moskowitz, H., "Alcohol Influences Upon Sensory Motor Function, Visual Perception, and Attention," Alcohol, Drugs, and Driving, ed. by M. W. Perrine, Report No. DOT-HS-801-096, Psychological Research Foundation of Vt., Inc., March, 1974, pp. 58-61.
61. Moskowitz, H., "A Behavioral Mechanism of Alcohol-Related Accidents," Proceedings of the First Annual Alcoholism Conference of the National Institute on Alcohol Abuse and Alcoholism, ed. by M. E. Chafetz, National Institute on Alcohol Abuse and Alcoholism, June, 1971, pp. 311-323.
62. McMurray, L., Emotional Stress and Driving Performance: The Effect of Divorce, Report 016, Division of Research, Administrative Services, State of Washington, Department of Motor Vehicles, August, 1968.



