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TECHNIQUES FOR PREDICTING HIGH-RISK DRIVERS FOR ALCOHOL COUNTERMEASURES
Volume II: User Manual

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16. Abstract

This User Manual, a companion to the Volume I Technical Report by the same name, is designed to aid the alcohol program administrator in his decisions concerning implementation of countermeasures to selected individuals or small groups of drivers. Volume I describes the development of statistical models to predict the probability of a future alcohol-related crash for six high-risk groups of drivers.

Volume II, the User Manual, presents the ways in which alcohol administrators can use the developed predictor models. The User Manual contains information concerning the inputs of the predictive models, information concerning the the cost and effectiveness of potential countermeasure programs, and procedures for conducting an economic analysis methodology to help the administrator decide whether or not a chosen countermeasure pays off in terms of reducing the predicted number of alcohol-related crashes. In addition, the final chapter of the manual presents a brief overview of evaluation techniques and problems as they relate to trial alcohol programs.

This Volume also contains computational forms for use in the economic analysis, a computer program that carries out the analysis methodology, and information concerning the background material on alcohol and driving and the statistical development of predictor models.

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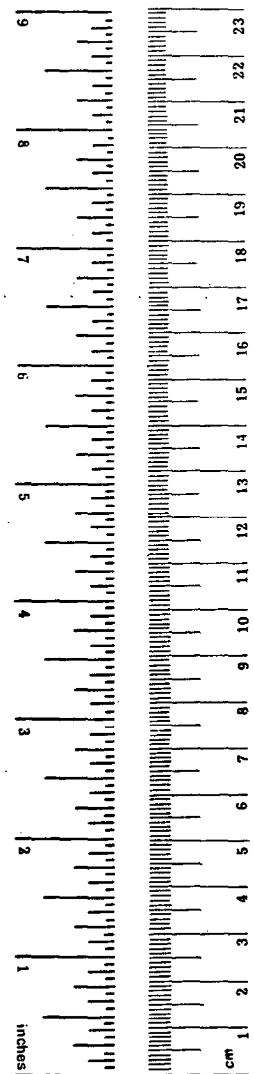
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

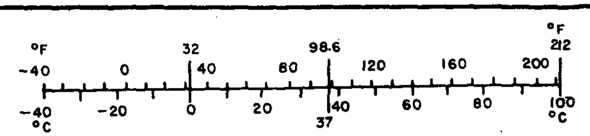
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



ADDENDUM

This manual may aid the reader to identify and treat drivers who are at a heightened risk of being involved in an alcohol related crash. As reported by the authors of this manual, there are gaps in the available information provided; for example, the estimates of effectiveness of a number of countermeasures recommended for use are not in the manual. In these cases users will have to supply their own estimates. In addition, it is hoped that users will perform their own effectiveness tests of the selected countermeasures and that they will funnel this information back to the NHTSA so that the utility of this manual can be determined and upgraded.

ACKNOWLEDGMENTS

While only three names appear on the title page, the complexity and length of this project required the dedicated efforts of many other people. The authors wish to express their appreciation to those HSRC and NHTSA staff members who made this report possible.

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

Chapter 1

OVERVIEW OF THE MANUAL

Introduction

The use of alcohol and its effects on driving skills, and ultimately, traffic crashes, is a problem repeatedly addressed by professionals working in the highway safety field. To the layman, the large number of traffic fatalities attributed directly to drunk drivers each year in any state indicates a well-defined, relatively simple problem, which, because it is so simply defined, can be eliminated.

Eliminating the alcohol-related (A/R) crash problem is, regretfully, not nearly as simple as defining the problem. In the past ten years, a large amount of money and effort has been expended in the area of alcohol and highway safety. What the administrators, enforcement personnel, and researchers have learned is that this problem, like many other problems associated with modifying human behavior, is not simple.

Alcohol-related highway safety funds have been used both in programs aimed at the general driving population or subpopulations (e.g., large scale DUI enforcement campaigns and public education programs for young drivers) and in programs aimed at more specifically defined groups (e.g., ASAP rehabilitation schools for convicted DUI offenders). This manual is the outgrowth of efforts in the latter area--efforts aimed at more efficiently identifying those drivers with a higher-than-average probability of being involved in an alcohol-related crash. This manual, and a companion report entitled, Techniques for Predicting High Risk Drivers for Alcohol Countermeasures. Volume 1: Technical Report, are the products of a study conducted for the National Highway Traffic Safety Administration (NHTSA) aimed at: (1) defining a set of driver subgroups who can be shown to be at a heightened risk of an A/R crash, (2) developing prediction models which will select individuals within these subgroups who are at an even more heightened risk of crash, (3) reviewing possible alcohol-related countermeasures or treatments which are applicable to these high-risk drivers, (4) developing an economic methodology which will aid program administrators in selecting the most cost-effective countermeasure for a given high-risk driver or group of drivers and (5) providing a brief discussion of basic issues related to evaluating the effects of an implemented countermeasure. This manual describes the components of the developed methodology.

Overview

The remainder of this first chapter is written to provide the program administrator with an overview of the system procedures and components described in Chapters 2 through 5 and the appendices. The system user who must be familiar with the details of the developed methodology is referred not only to the remaining chapters of the manual but also to the Volume 1 report.

The purpose of the manual.

The basic purpose of this manual is to provide a methodology for identifying high-risk drivers within certain driver populations and for comparing the cost and benefits of potential countermeasure programs.

The manual is designed for use by alcohol safety program administrators in the broadest sense of the term. Hopefully, the manual will be valuable to driver licensing program administrators, to governor's highway safety representatives and their alcohol program specialists and evaluation staffs, to the judiciary in their decisions concerning the sentencing of alcohol traffic offenders, to motor vehicle department administrators involved with driver improvement programs, to directors of local alcohol rehabilitation programs, and to many other professionals in the field.

A study of alcohol-related driving problems indicates that program administrators appear to need four tools to help them in their work: (1) a better method of identifying drivers likely to be involved in A/R crashes; (2) a listing of available countermeasures including information concerning costs, effectiveness, target groups, length of countermeasure effect, etc.; (3) a method for determining whether the costs of a given countermeasure will be less than the benefits derived from it (or at least whether the cost-benefit ratio is higher than such ratios for other countermeasures); and (4) guidelines for conducting well-designed evaluations of the countermeasure activities to establish levels of effectiveness. This manual is designed to provide these tools.

A basic component of this methodology is a set of predictor equations or models that will allow a user to estimate the probability of future A/R crash involvement for a given individual who can be defined by certain characteristics. One model has been developed for each of six high-risk subpopulations of drivers. The groups are:

1. Young males, 16-20 years old
2. Males, 21-24 years old
3. Persons recently divorced
4. Persons recently released from prison
5. Persons recently convicted of driving under the influence
6. Persons accumulating three or more traffic violations in a five-year period (the high violation group)

As is explained in detail in the companion Volume 1 report, these groups were identified as having an elevated risk of A/R crash involvement through a review of past research literature and analysis of North Carolina accident data. While many other potential high-risk groups were considered, the best information available from these reviews and related analyses led NHTSA and HSRC to include these six subpopulations in subsequent analyses. The original NHTSA decision to define high-risk groups rather than to use the entire driving population was related to the need to define homogeneous parts of the entire driving population who could be easily identified and who, as a group, would be more susceptible to similar treatments. The remaining chapters in this manual will describe the methodology developed to identify the individuals who are at an even higher risk of A/R crash involvement than are others in these groups and to analyze the costs and benefits of selected countermeasures.

Chapter 2 provides detailed information concerning the necessary inputs and resultant outputs for the six predictive models developed, the individuals to whom each model is to be applied, and the appropriate point in time for model application. While each of the six models requires slightly different inputs, all inputs are composed of information which should be available to alcohol program administrators through state records systems. Basically, these inputs are either demographic (e.g., age, sex), sociological (e.g., presence of a prison record or a recent divorce), or related to the individuals past driving behavior (e.g., number of DUI convictions, number of recent crashes, etc.). The predictive model output in each case is the

<u>probability that the driver described will be involved in an alcohol-related crash during a one-year time period</u>. These probabilities are presented in Probability Tables, with one table developed for each of the six high-risk groups. An example of a Probability Table is presented on the next page.

Chapter 3 presents the second tool--a description of potential countermeasure programs. A short narrative describing the content of the treatment program along with information on the cost, level of effectiveness, period of effectiveness, and suitable target groups has been extracted from research studies and program implementation reports for the following countermeasure programs:

1. Warning letters
2. Driver improvement clinics
3. Hearing officer sessions
4. Probationary license for first offenders
5. Short-term rehabilitation programs -

   Type 1 Alcohol Safety Schools
   Type 2 Alcohol Safety Schools
   Type 3 Alcohol Safety Schools
6. Short-term rehabilitation - Power motivation training
7. Suspension or revocation of driver license
8. Group therapy
9. Alcoholics Anonymous
10. Psychotherapy
11. Aversion therapy
12. Chemotherapy

It should be noted that these countermeasures are individual or small-group oriented. More general countermeasures such as enforcement and public education are excluded, not because of any judgment concerning effectiveness, but because the goal of this project is to better identify drivers who are much more likely to be involved in a future A/R crash than the general population, and to treat these individuals or small groups of drivers. The more general countermeasures are designed for use with large driver populations when no information concerning individuals is available.

As will be discussed in both Chapters 3 and 5, a major problem with the methodology is existing gaps in the information concerning the cost, effectiveness, etc., of the treatment programs listed above. There is a continuing

Probability Table

for

16-20 Year Old Males

Subgroup	Days Under Suspension Or Revocation In Previous Year	Violations in Previous Year	Night Crashes In Previous Two Years	Citations for Alcohol-Related Violations At Night	Output = Predicted Probability Of An Alcohol-Related Crash In Next Year
1	0	0	0	0	.00933
2	0	0	0	1+	.00933
3	0	0	1+	0	.01788
4	0	0	1+	1+	.01788
5	0	1+	0	0	.01664
6	0	1+	0	1+	.03956
7	0	1+	1+	0	.02519
8	0	1+	1+	1+	.04810
9	1+	0	0	0	.02533
10	1+	0	0	1+	.04824
11	1+	0	1+	0	.03387
12	1+	0	1+	1+	.05679
13	1+	1+	0	0	.02533
14	1+	1+	0	1+	.04824
15	1+	1+	1+	0	.03387
16	1+	1+	1+	1+	.05679

need for sound evaluation of these and other treatments. However, the information presented in Chapter 3 represents a current listing of available data.

Chapter 4 presents the details of a method for conducting an economic analysis of a chosen countermeasure applied to a target subgroup. Outlined here is the step-by-step procedure by which the output from the predictive model and the outputs from the countermeasure data are combined. The economic analysis methodology used will calculate the Net Discounted Present Value of program costs and future program benefits. For economic analysis purposes, benefits are stated in terms of dollar savings for fatal crashes, injury crashes, and property damage crashes. Benefits are also presented in terms of the predicted number of crashes reduced over the life of the treatment. If the user does not wish to use monetary values for accident costs, he can use the latter outputs to calculate crashes reduced per treatment dollar by any or all of the three severity levels. The economic methodology has been computerized for user convenience, and a listing of the computer program is presented in Appendix C. Example output tables from this program can be found in Chapter 4, Figures 4.1 and 4.2.

Chapters 2 through 4 thus present a methodology aimed at aiding the administrator in his decision concerning whether or not to implement a given countermeasure--essentially a "yes-no" decision. That is, even though a high-risk group of drivers has been identified, will the benefits of a given treatment be predicted to be great enough to justify the treatment costs? A positive answer to this question might result in countermeasure implementation; a negative answer might lead the administrator to further search for a different treatment or a different high-risk group. This economic analysis methodology is based on the inputs described earlier, including the effectiveness level of the treatment. As noted, there are gaps in this necessary data. Effectiveness levels for many treatments are unknown, and there is a pressing need for alcohol program administrators to help fill these gaps by increasing both the quality and quantity of alcohol countermeasure evaluation. It is because of this need that Chapter 5 is included in the manual.

This final chapter in the manual concerns the last tool--a methodology for evaluating the implemented alcohol countermeasure programs. Hopefully, the material in this final chapter will help meet this need by providing the program administrator and technicians with some basic concepts of evaluation methods. Obviously, this rather brief chapter cannot provide a detailed study of evaluation methods. However, knowledge of the basic principles described herein can aid an administrator both in planning his own evaluation and in interpreting and judging the validity of alcohol-related research studies. The chapter contains information concerning types of evaluation, criteria, evaluation designs, and appropriate statistical tests, and presents a step-by-step discussion of one example situation.

Following Chapter 5 are appendices which present reference information cited in earlier chapters. Appendix A contains information from Volume 1 concerning statistical development of the predictive models. This material is included for the user who might wish to build models based on data from his own state. Appendix B contains sample forms for use by administrators in performing the economic analysis, and Appendix C contains a program listing for the computerized economic analysis.

The manual user should realize that this material is only one of many tools needed by the program administrator in making program implementation decisions. The material is not without flaws. All of the required inputs to the economic methodology are not currently available. Thus, the final results derived will only be as accurate as the inputs provided by the manual user himself. However, even with this restriction, the manual can provide needed information concerning the cost-effectiveness of various highway safety countermeasures. This information is basic to any decision-making process.

The Alcohol/Driving Program--Background Material

The following general material is related to the overall problem of alcohol and driving. It is presented as reference material for administrators to use, and as part of the underlying rationale for conducting research in the alcohol/driving area and developing methodologies such as the one developed in this current study. References cited are listed at the end of this chapter.

The research to date has identified a subset of the driving population who are at a much higher risk of being represented in a fatal crash--those with blood alcohol concentrations of greater than .10 percent by weight. While percentages of intoxicated drivers vary according to crash type, location of study, and other factors, there is strong evidence that alcohol is involved in approximately one-half of the traffic fatalities each year in the U.S. (McBay, 1972; Perrine, et al., 1971).

In multi-vehicle crashes where a second driver is not considered to be at fault, 31 percent of the drivers who are killed have blood alcohol readings above .10 percent. In single-vehicle crashes, the figure is even higher--over 54 percent of the drivers who are killed are legally intoxicated by our current definition. When all types of crashes in which a driver was killed are grouped together, over 40 percent of the drivers are at or above the .10 blood alcohol concentration (BAC) level (Perrine, et al., 1971).

Data providing evidence of overrepresentation of intoxicated drivers in fatal crashes are obtained in studies of the relative risks of being involved in a crash at various alcohol levels. In comparing crash-involved and non-crash involved drivers, persons with blood alcohol levels of approximately .10 percent are from two to five times more likely to be involved in a crash than those persons with blood alcohol readings below .05 (the latter group includes persons with no blood alcohol percent) (Lucas, et al., 1955; Holcomb, 1938; Hurst, 1970). For the group with blood alcohol readings of .15 percent or greater, the relative risk of being involved in a crash has been estimated to be 10 to 25 times greater than the risk for the .05 percent or less group (Borkenstein, et al., 1963; Hurst, 1970; Perrine, et al., 1971).

The involvement of many intoxicated drivers in fatal and non-fatal crashes does not mean that this subset of drivers is easy to distinguish from the average driver. Alcohol usage is part of our society. Based on available data, it is estimated that approximately 70 percent of the adult population in the U.S. uses alcohol to some degree (Cahalan, et al., 1969). In addition, one study has indicated that, when questioned about their drinking and driving habits, over 50 percent of drivers state that, at some time, they have driven after drinking (U.S. Department of Transportation, 1968). Fortunately, this drinking/driving process is not frequent enough to produce at any one time a large proportion of drinking drivers on the roadway, even at the higher-risk times (i.e., late evenings, weekend nights, etc.). When non-crash-involved drivers who are on the road during these peak alcohol periods are stopped and given breath tests, over 85 percent have had no alcohol, and between 95 and 99 percent have BAC's of less than .10 percent (Perrine, et al., 1971). Thus, even at these peak times, only one to four percent of the drivers on the road are legally intoxicated according to most state laws. This small minority is vastly overrepresented in fatal crashes.

The problem of false positives.

Knowing that between one and four percent of the drivers on the road cause the bulk of the problem, a solution should be relatively easy--simply treat these drivers appropriately. However, even after "identifying" this small proportion with the best available tests, countermeasure program administrators encounter the problem of incorrectly predicting that a specific driver will be involved in a crash--the problem of false positives. This problem results from the very low probability of an individual driver being involved in an A/R crash in a given time period and the predictive inaccuracy of the test used.

As an illustrative example, let us examine the effects of using as a very simplistic test whether or not a person has been convicted of DUI. If so, the person will be "treated"--i.e., a countermeasure will be implemented. Although administrators may not always recognize this, the implied assumption being made in this process is that all these identified drivers will become involved in subsequent A/R crashes if no treatment program is introduced. This assumption is basic to this and all other identification/treatment programs.

In North Carolina, this would mean that approximately 41,000 drivers per year would undergo some form of treatment. Analysis of accident data indicates that approximately five percent of this subgroup of drivers are involved in an A/R crash in a given year. Thus, 38,950 (95 percent) of the drivers who have been predicted to be in A/R crashes will not be. For every "true-positive," we will have also identified 19 false positives.

Quite obviously, this has serious implications when choosing countermeasures to be applied to the identified group. First, some countermeasure should be applied to these drivers convicted of DUI. The "do-nothing" alternative appears impractical since persons in this identified group are 4 to 20 times more likely to be involved in an A/R crash than the average driver--a high overrepresentation. However, since in this case the prediction is wrong for 19 drivers out of 20, the application of a harsh countermeasure (such as license suspension or revocation) to all 41,000 drivers is not feasible. Such an action unfairly penalizes the overwhelming majority of the "treated" group. Similarly, implementing a very expensive treatment program for this group might also not be feasible: a great deal of money would be spent to affect 1 of 20 drivers treated.

The above example is not an over-statement of the problem of false positives. The problem exists in the real world and will continue to be a part of any effort to predict future driving records and implement countermeasures. No prediction equation can accurately identify drivers who will be involved in A/R crashes without also identifying false positives. Furthermore, some drivers who will have an accident in a given year will improperly be classed as accident-free drivers--false negatives. The number of false positives and false negatives in any prediction is related to each other. If this prediction equation is changed to decrease false negatives (i.e., to identify a high proportion of all drivers who will indeed have crashes), then there is also an increase in the number of false positives. The converse also is true.

In summary, the fact that these false positives (and false negatives) exist in prediction of future driving records emphasizes two important points that both alcohol program administrators and researchers must keep in mind. First, the false positives, because of political necessity, affect the choice of countermeasure. Second, the administrator and researcher must continue to work as a team to insure that the best available predictive models are used and that better models are being built. Indeed, the goal of this project and related future projects is to increase the predictive efficiency (i.e., accuracy) of such models--to reduce the number of false positives while keeping the number of false negatives low. As will be seen, the models developed in this project are indeed more accurate than the simplistic model used in the above example. Even better models will, in all likelihood, be developed in the future as the state of the art progresses. By the nature of his job, the administrator is forced to make daily decisions concerning problem drivers and countermeasures. Even with the problem of imperfect accuracy, the predictive models developed can aid in these decisions.

Problems related to the state-of-the-art of alcohol countermeasures.

In the preceding discussion, it has been implicitly assumed that there are treatments which have been shown to be effective in reducing A/R crashes if applied to individuals who have been identified as high-risk drivers. It has also been implicitly assumed that these programs have been shown to be effective through good scientific data and that little question exists concerning how well they operate.

Unfortunately, this is not the case. At present, there are very few programs that have been shown by good evaluations to be effective in reducing A/R crashes. Obviously, this is not because different approaches have not been tried. Throughout at least the past ten years, efforts from many different directions have been attempted to deal with the drinking driver. Most important, of course, are the ASAP-related projects which have been and are continuing to be implemented across the nation.

Unfortunately, because of problems in the way programs have been implemented, very few good evaluations have been conducted. When sound evaluations have been carried out, countermeasure programs have not been as effective in reducing A/R crashes as had been hoped. The problem is that in working with drinking drivers, we are attempting to influence human behavior, an extremely difficult task. While researchers and administrators in the highway safety area have not been tremendously successful in influencing human behavior, the situation is not hopeless. Work is continuing and well-designed efforts are being implemented both to identify countermeasure activities which affect drivers and to obtain good data concerning levels of countermeasure effectiveness. Chapter 3 indicates a number of countermeasure programs that, based on some data, appear to be effective A/R crash countermeasures. These countermeasures and others like them will be the focus of our efforts.

Perhaps the greatest breakthrough in sound evaluation, however, could result from the involvement of state alcohol program administrators, judicial officials, and enforcement personnel in a process which: (1) attempts new or improved countermeasure activities and (2) correctly evaluates the effects of such activities.

Because the majority of the funding for alcohol countermeasures will continue to be state funds, the state administrator will continue to have a large degree of control over program planning and implementation. It appears that many alcohol safety program administrators have certain countermeasure programs which they feel would be effective given the accident and alcohol usage circumstances in their state. Thus, ample opportunity exists to implement numerous countermeasure activities on a trial basis in a number of these jurisdictions.

It is most important (particularly for future alcohol programs) that the current administrator evaluate these trial efforts and validate the results of these programs. The critical need for sound evaluation will be met to some extent through NHTSA's 402 and 403 programs, demonstration projects, and related efforts. However, just as in all other areas of highway safety, the majority of the work will have to be done at the state level by the state administrator. Without true measures of program effectiveness, the administrator is in the position of having to guess the best way to spend limited highway safety dollars. However, through a process which involves careful planning for sound evaluation early in program implementation phases (a process which must be initiated by the administrator), the needed knowledge can be obtained. This may well be the most valuable aspect of current alcohol safety programs. As indicated above, because of the great need for this knowledge, the final chapter of this manual, Chapter 5, presents a brief overview of sound evaluation techniques that can be used in the area of alcohol countermeasures.

In summary, this manual and the companion Volume 1 project report have been prepared to provide tools needed by the alcohol program administrators, tools which can help him more effectively identify potential high-risk drivers, better select appropriate treatment, and more efficiently evaluate the results of his work. Hopefully, the material presented in the following chapters will serve as an aid to the administrator in his decisions concerning what may be the most important single area of the highway safety field.

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Chapter 2

THE PREDICTIVE MODELS - THEIR INPUTS AND OUTPUTS

The methodology presented in this manual involves four basic tools. The first of these tools--a method for identifying drivers who are likely to be involved in alcohol-related (A/R) crashes--is presented here. The method employs a series of predictive models designed to calculate the probability that a driver described by certain characteristics will be involved in an A/R crash within a one-year period. Models were developed for six high-risk groups. Within each of these high-risk groups, special subgroups of drivers with special characteristics were identified; also, the probability of their involvement in an A/R crash has been determined.

It should be noted that the models are based solely on North Carolina data. The raw data employed in the model development were the driving records, accident data, and demographic and sociological information extracted from files concerning N.C. drivers. Obviously, the results of the models--the predicted involvement probabilities--are influenced by the composition of the data used to build these models. Because crash and alcohol usage information in North Carolina may vary from those of other states, the models presented may differ from a set of models developed with data from another state or jurisdiction. It was anticipated, however, that the N.C. data would be similar to that from some other areas, particularly the more rural sections of the nation. [For the user who wishes to compare the situation within his or her own jurisdiction with that of North Carolina, information concerning the N.C. data is presented in Volume 1, Chapter 4.]

The High-Risk Populations

As indicated in Chapter 1, one predictive model was developed for each of six high-risk groups of drivers. The process by which these groups were defined included reviewing past research literature and analyzing North Carolina accident data. Many potential high-risk groups exist. These were examined and a decision concerning which groups to concentrate study efforts on was made by NHTSA and HSRC based on the best current research information and on N.C. data analysis. The reader desiring additional information concerning the justification for designating these groups as high-risk is referred to Volume 1. The remainder of the manual will be concerned with the following groups:

1. Young males, 16-20 years old
2. Males, 21-24 years old
3. Persons recently divorced
4. Persons recently released from prison
5. Persons convicted of DUI in most recent three years
6. Persons accumulating three or more traffic violations in the most recent five years

While a detailed discussion of the models and countermeasures is presented in the next section and in Chapter 3, the user should note one point of interest at this time. The high-risk subpopulations are not mutually exclusive, i.e, a given driver might fall into more than one group. For example, a 23-year-old male who was convicted of DUI within the last three years would fall into Group 2 and Group 5. Thus, the user is given a choice of which model to use. If an individual falls into two groups, the administrator should make the important choice of which model to use based on (1) whether the prescribed point of intervention fits the situation in the state or locality, and (2) which of the optional high-risk models results in the highest probability for the individual in question. The highest accident involvement probability should be used in all later economic analysis steps.

The remainder of this chapter includes detailed information on the model outputs, input requirements, instructions for calculating expected group crash frequencies by severity level, and some general cautions concerning the effect a low probability has on the choice of countermeasure.

Model Outputs

The statistical processes involved in building predictive models may be generalized to different sets of data, and the resulting output forms of the models will differ. Because of the discrete nature of the data used and the goal of predicting the frequency of future A/R crash involvement, the models developed in this project estimate the probabilities of being involved in an A/R accident. That is, for a driver with a certain set of characteristics, the models will calculate an estimate of <u>the probability that the driver will be involved in an alcohol-related crash during a</u>

one-year time period. For example, 0.45 percent of the general population of N.C. drivers are involved in A/R crashes in a given year. Thus, if one were to predict whether or not a given driver would be involved in a crash knowing only the fact that he was in the general population, the best estimate of this probability would be .0045. Based on outputs of the statistical analyses of this project, this predicted probability for special subgroups in the population has been calculated. For example, for women over the age of 25 with no accidents or violations (subsequently no days under suspension or revocation), the probability of involvement in an A/R crash in a given year drops to .0005, a very low probability. In contrast, for one special subgroup--males between the ages of 21 and 24 with certain violations, accidents, and license revocations in their past history--the probability of being involved in an A/R crash is .0678. This probability is 15 times greater than that for the entire general population and 136 times larger than that for the low-risk group of females. The calculation and use of these types of probabilities will be discussed in the remaining sections of the manual.

Model Form and Inputs

To predict the probabilities described above requires certain characteristics of the driver, or group of drivers, as inputs to the models. These inputs differ from model to model, but all are either demographic (e.g., age, sex), sociological (e.g., presence of a prison record, experienced a recent divorce), or are related to the individual's past driving behavior (e.g., number of DUI convictions, number of crashes in previous year, number of night violations, etc.). Because the models developed are categorical data models, all input variables are coded into two or more categories--either yes-no, some-none, <25 years old-≥25 years old, etc. This coding simplifies the data demands to some extent.

The general form of each of the six final models may be depicted as

$$P = \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_i X_i$$

where P is the estimated probability of an A/R crash, the X's are variables which denote the absence or presence of certain characteristics for a given driver (or group of drivers) within a high risk group and the β's represent coefficients (or probabilities) related to these characteristics. (As reference material for the statistician, Appendix A contains more detailed statistical information concerning the model development procedures and results.) The final model for each high-risk group is presented along with the design matrix, β vector, χ^2 due to the model and due to error, and an R^2 value (a measure of how well the final predictor model accounts for all the actual A/R accidents which occurred in the N.C. data that were used to build the particular model.)

Possibly more interesting to the non-statistician are the tables of probabilities presented in the following section of this chapter for each high-risk group. These Probability Tables are designed to present the inputs and outputs of the statistical models in a condensed form for program administrators and technicians. Here the predicted probabilities have been calculated for each subgroup in a high-risk population. The user only needs to know the coded input characteristics for a given driver or group to read off the relevant probability. An example Probability Table for the 16 to 20-year-old's model is presented on the following page. The input characteristics necessary in the use of this model are listed vertically above the second through fifth columns.

Here, for example, reading across the first row, the probability of an A/R crash for a 16 to 20-year-old male with no days under S/R, no violations, no night crashes, and no night alcohol citations is .00933. For a 16-20 year old male with some days under S/R, no violations, some night crashes, and night alcohol citations, the probability of involvement in an A/R crash is .05679, as indicated in row 12.

Obviously, the particular driver characteristics in this table are by no means the only characteristics which might be used to predict accident involvement for this subgroup. In the model building process, many additional driver record and demographic characteristics were analyzed both separately and in combination to identify the best predictors. The combination of characteristics indicated above provides the best prediction model for the 16 to 20-year-old males.

A slightly different interpretation of these results (the predicted probabilities), which will be very important in the economic analysis methodology presented in Chapter 4, involves groups of drivers rather than individual drivers. To estimate the predicted number of A/R crash-involved drivers within a given subgroup of drivers who all have the same

Probability Table

for

16-20 Year Old Males

Subgroup	Days Under Suspension Or Revocation In Previous Year	Violations in Previous Year	Night Crashes In Previous Two Years	Citations for Alcohol-Related Violations At Night	Output = Predicted Probability Of An Alcohol-Related Crash In Next Year
1	0	0	0	0	.00933
2	0	0	0	1+	.00933
3	0	0	1+	0	.01788
4	0	0	1+	1+	.01788
5	0	1+	0	0	.01664
6	0	1+	0	1+	.03956
7	0	1+	1+	0	.02519
8	0	1+	1+	1+	.04810
9	1+	0	0	0	.02533
10	1+	0	0	1+	.04824
11	1+	0	1+	0	.03387
12	1+	0	1+	1+	.05679
13	1+	1+	0	0	.02533
14	1+	1+	0	1+	.04824
15	1+	1+	1+	0	.03387
16	1+	1+	1+	1+	.05679

characteristics, the appropriate probability in the Probability Table is simply multiplied by the number of drivers in the subgroup. For example, suppose an administrator could identify 1000 young male drivers in his state who had accumulated no days under S/R and no nighttime crashes in the previous year, but who all had accumulated at least one violation and at least one citation for a nighttime alcohol-related offense. Row 6 of the Table would indicate to the administrator that the predicted probability for any one driver in this category being involved in an A/R crash is .03956. By multiplying this probability by the number in this subgroup (1000), the administrator would predict that

$$.03956 \times 1000 = 39.56 \text{ drivers}$$

would be involved in an alcohol-related crash in the upcoming year. Whether or not these 40 accident-involved drivers is a large enough target group to ensure that a given countermeasure treatment is cost-effective is a question pursued in Chapter 4.

Obviously, this example is rather simplified. There may not be a homogeneous subgroup of 1000 young males available to a safety program administrator. However, there may be many smaller homogeneous groups that fit the characteristics of different rows in the Table. If the same treatment is appropriate to all these smaller groups, the total number of young drivers predicted to be involved in A/R crashes in the next year could be estimated by calculating the predicted number in each subgroup (using each relevant matrix row) by the same calculation as above, and then summing these individual figures.

In summary, for the manual user, the Probability Table for each high-risk group as presented on the next seven pages is the first important tool.

Calculation of Expected Crash Frequencies by Severity Level

The principal information required by the economic analysis methodology in Chapter 4 is the number of expected alcohol-related crashes for the subgroup of drivers under study. The method for estimating the crash frequency was presented earlier--the appropriate predicted probability is multiplied by the number of drivers in the subgroup and, if more than one subgroup is under examination, the individual expected subgroup frequencies are summed.

HIGH RISK GROUP 1 - MALES, AGE 16-20

Group Description - This model is appropriate for use with males who are 16, 17, 18, 19, or 20 years old.

Required Input Characteristics:

1. Whether or not driver license was suspended or revoked for one or more days in the previous year.
2. Whether or not the driver accumulated one or more total violations in the previous year.
3. Whether or not the driver was involved in one or more reportable night crashes during the previous two years.
4. Whether or not the driver had accumulated one or more citations (not necessarily convictions) for alcohol-related violations at night during the previous year.

Point of Intervention - This model can be applied to any 16-20-year-old driver at any time after he has been licensed for one year.

Probability Table

Subgroup	Days Under S/R	Total Violations	Night Crashes	Alcohol Citations at Night	Predicted Probability
1	0	0	0	0	.00933
2	0	0	0	1+	.00933
3	0	0	1+	0	.01788
4	0	0	1+	1+	.01788
5	0	1+	0	0	.01664
6	0	1+	0	1+	.03956
7	0	1+	1+	0	.02519
8	0	1+	1+	1+	.04810
9	1+	0	0	0	.02533
10	1+	0	0	1+	.04824
11	1+	0	1+	0	.03387
12	1+	0	1+	1+	.05679
13	1+	1+	0	0	.02533
14	1+	1+	0	1+	.04824
15	1+	1+	1+	0	.03387
16	1+	1+	1+	1+	.05679

HIGH RISK GROUP 2 - MALES, AGE 21-24

Group Description - This model is appropriate for use with males who are 21, 22, 23, or 24 years old.

Required Input Characteristics:

1. Whether or not driver license was suspended or revoked for one or more days in the previous four years.
2. Whether or not the driver accumulated one or more reckless driving violations* in the previous four years.
3. Whether or not the driver had accumulated one or more alcohol (DUI) violations in the previous four years.
4. Whether or not the driver had been involved in one or more alcohol-related crashes in the past two years.

Point of Intervention - This model can be applied to any 21-24 year old driver at any time after he has been licensed for four years.

Probability Table

Subgroup	Days Under S/R	Reckless Violations	DUI Violations	Alcohol Related Crashes	Predicted Probability
1	0	0	0	0	.00698
2	0	0	0	1+	.02051
3	0	0	1+	0	.02051
4	0	0	1+	1+	.03404
5	0	1+	0	0	.01620
6	0	1+	0	1+	.04804
7	0	1+	1+	0	.02973
8	0	1+	1+	1+	.06157
9	1+	0	0	0	.01620
10	1+	0	0	1+	.02973
11	1+	0	1+	0	.02973
12	1+	0	1+	1+	.04326
13	1+	1+	0	0	.02240
14	1+	1+	0	1+	.05424
15	1+	1+	1+	0	.03593
16	1+	1+	1+	1+	.06777

*See Appendix A, page A-23 for more detailed description of this category.

HIGH RISK GROUP 3 - PERSONS RECENTLY DIVORCED

Group Description - This model is appropriate for use with persons who were divorced during the previous year.

Required Input Characteristics:

1. Whether or not the driver had accumulated one or more alcohol (DUI) violations in the previous four years.
2. Whether or not the driver had accumulated one or more reckless driving violations* in the previous three years.

Point of Intervention - This model can be applied to any driver who was divorced in the past year at any time after he had been licensed for four years.

Probability Table

Subgroup	DUI Violations	Reckless Violations	Predicted Probability
1	0	0	.00570
2	0	1+	.02118
3	1+	0	.03571
4	1+	1+	.05119

*See Appendix A , page A-23 for more detailed description of this category.

HIGH RISK GROUP 4 - PERSONS RECENTLY RELEASED FROM PRISON

Group Description - This model is appropriate for use with any driver who has been released from prison within the previous 3 years.

Required Input Characteristics:

1. Whether or not the driver has accumulated one or more administrative violations during the past two years.
2. Driver age - two levels - 21-30, all other

Point of Intervention - This model can be applied to any driver who was released from prison within the past three years at any time after he has been licensed for four years.

Probability Table

Subgroup	Administrative Violations	Age	Predicted Probability
1	0	Other	.0184
2	0	21-30	.0315
3	1+	Other	.0602
4	1+	21-30	.0734

HIGH RISK GROUP 5 - DRIVERS CONVICTED OF DUI

Group Description - This model is appropriate for use with any driver who has been convicted of DUI in the previous three years.

Required Input Characteristics:

1. Driver age - three levels - 0-20, 21-25, 26+
2. Whether or not the driver has accumulated one or more speeding violations* in the previous year.
3. Whether the driver license has been suspended or revoked for less than 185 total days or 185 days or more during the past three years.
4. Whether or not the driver has accumulated one or more reckless driving violations* in the previous year.

Point of Intervention - This model can be applied to any driver convicted of DUI within the previous three years at any time after he has been licensed for three years.

Probability Table

Subgroup	Age	Speeding Violations	Days Under S/R	Reckless Violations	Predicted Probability
1	0-20	0	<185	0	.02477
2	0-20	0	<185	1+	.03087
3	0-20	0	185+	0	.05830
4	0-20	0	185+	1+	.06440
5	0-20	1+	<185	0	.03738
6	0-20	1+	<185	1+	.04348
7	0-20	1+	185+	0	.07091
8	0-20	1+	185+	1+	.07701
9	21-25	0	<185	0	.02477
10	21-25	0	<185	1+	.03087
11	21-25	0	185+	0	.02919
12	21-25	0	185+	1+	.03530
13	21-25	1+	<185	0	.03738
14	21-25	1+	<185	1+	.04348
15	21-25	1+	185+	0	.04180
16	21-25	1+	185+	1+	.04790
17	26+	0	<185	0	.01507
18	26+	0	<185	1+	.02118
19	26+	0	185+	0	.01950
20	26+	0	185+	1+	.02560
21	26+	1+	<185	0	.02768
22	26+	1+	<185	1+	.03378
23	26+	1+	185+	0	.03811
24	26+	1+	185+	1+	.03821

*See Appendix A, page A-23 for more detailed description of this category.

HIGH RISK GROUP 6 - HIGH VIOLATION DRIVERS

Group Description - This model is appropriate for use with drivers who have accumulated 3 or more violations in the previous five years.

Required Input Characteristics

1. Driver age - either 0-20 or 21+
2. Driver sex - male or female
3. Whether or not the driver license has been suspended or revoked for one or more days in the previous year.
4. Whether or not the driver has been involved in one or more alcohol related crashes in the past two years.
5. Whether or not the driver had been involved in one or more nighttime crashes in the previous two years.

Point of Intervention - This model can be applied to any high violation driver at any time after he has been licensed for two years.

Probability Table

Subgroup	Age	Sex	Days Under S/R	Alcohol Related Crashes	Nighttime Crashes	Predicted Probability
1	0-20	M	0	0	0	.03946
2	0-20	M	0	0	1+	.04620
3	0-20	M	0	1+	0	.04288
4	0-20	M	0	1+	1+	.04962
5	0-20	M	1+	0	0	.03946
6	0-20	M	1+	0	1+	.06780
7	0-20	M	1+	1+	0	.04288
8	0-20	M	1+	1+	1+	.07122
9	0-20	F	0	0	0	.01739
10	0-20	F	0	0	1+	.02413
11	0-20	F	0	1+	0	.02080
12	0-20	F	0	1+	1+	.02756
13	0-20	F	1+	0	0	.01739
14	0-20	F	1+	0	1+	.02413
15	0-20	F	1+	1+	0	.02082
16	0-20	F	1+	1+	1+	.02756

Probability Table (cont.)

Subgroup	Age	Sex	Days Under S/R	Alcohol Related Crashes	Nighttime Crashes	Predicted Probability
17	21+	M	0	0	0	.01739
18	21+	M	0	0	1+	.02413
19	21+	M	0	1+	0	.05133
20	21+	M	0	1+	1+	.05807
21	21+	M	1+	0	0	.02255
22	21+	M	1+	0	1+	.02929
23	21+	M	1+	1+	0	.02598
24	21+	M	1+	1+	1+	.03272
25	21+	F	0	0	0	.00589
26	21+	F	0	0	1+	.01264
27	21+	F	0	1+	0	.00932
28	21+	F	0	1+	1+	.01606
29	21+	F	1+	0	0	.01739
30	21+	F	1+	0	1+	.02413
31	21+	F	1+	1+	0	.02082
32	21+	F	1+	1+	0	.02756

For the economic analysis to be as accurate as possible, the expected crash frequencies are then subdivided into three severity levels--fatal crashes, injury crashes, and property damage only (PDO) crashes. Each of these severity levels is assigned a different dollar cost in the economic analysis.

To calculate these expected frequencies, factors developed from alcohol-related crashes which have occurred in the past should be used. For example, a fatal A/R crash factor for a given high-risk group can be derived by dividing the number of fatal A/R crashes involving drivers in the group by the total number of A/R crashes involving drivers in the group (note: total A/R crashes, not just total crashes). Similar proportional factors can be calculated for injury and PDO crashes. Each of these factors is multiplied by the total expected crash frequency for the subgroup(s) under study, which produces the number of expected crashes by severity level. (This assumes that all subgroups within a given high-risk group have the same proportions of fatal, injury, and PDO A/R crashes, but not necessarily equal frequencies.)

If possible, the manual user should develop his own severity factors based on the A/R accident experience in his own jurisdiction. Since the required data exist in many statewide traffic records systems, these estimations should be possible.

In order to further clarify this procedure for the user who can develop his own factors, and in order to present factors which might be used by users whose data systems do not make this calculation possible, the following information is presented.

In the North Carolina data used in the development of the model for the 16-20 year old males, there were 2041 total alcohol-related crashes. Of these, 81 were fatal crashes, 942 were non-fatal injury crashes and 1018 were PDO crashes. Using these data, the severity factors for the total high-risk group are calculated as follows:

Fatal Severity Factor:

$$\frac{\text{81 Fatal A/R Crashes}}{\text{2041 Total A/R Crashes}} = .0397$$

Injury Severity Factor:

$$\frac{942 \text{ Injury A/R Crashes}}{2041 \text{ Total A/R Crashes}} = .4615$$

PDO Severity Factor:

$$\frac{1081 \text{ PDO A/R Crashes}}{2041 \text{ Total A/R Crashes}} = .4988$$

Using these factors under the assumption of equal proportions across all subgroups, and the 40 expected crashes calculated in the example on page 20, the number of expected crashes by severity level for this specific subgroup would be:

40 x .0397 = 1.6 expected fatal crashes
40 x .4615 = 18.5 expected non-fatal injury crashes
40 x .4988 = 19.9 expected PDO crashes

These expected frequencies would then be used in the economic methodology in Chapter 4.

Similar severity factors can be calculated for every high-risk group. These calculations have been carried out with the N.C. data used in the model development and the results are shown in Table 2.1. Again, these factors can be used by manual users with limited data systems. If appropriate data banks exist, the user should calculate his or her own factors.

Problems Related to the Size of the Estimated Probabilities

The reader who has carefully studied the Probability Tables on pages 20-26, has noted one very important fact. While the models developed for these high-risk drivers identify subclasses of drivers with greatly elevated risk of A/R crash involvement (risks which are sometimes over twenty times greater than those for the average driver), the probability of these highest risk drivers becoming involved in an A/R crash during a one-year period is still quite low--the highest probabilities are slightly less than 1 chance in 10.

Table 2.1 . A/R crash severity factors for the high risk groups.

High-Risk Group	Severity Factors: Fatal	Injury	PDO
1. Young males, 16-20	.0397	.4615	.4988
2. Males, 21-24	.0319	.4923	.4758
3. Persons recently divorced	.0184	.5441	.4375
4. Persons recently released from prison	.0355	.5025	.4619
5. Persons convicted of DUI in most recent three years	.0147	.4565	.5288
6. Persons accumulating 3 or more traffic violations	.0198	.4750	.5052

Because of these low probabilities, the program administrator must be continually aware that if he is studying even a small subgroup of high-risk drivers with identical characteristics (say 100), he will predict that somewhat less than 10 of these drivers will be involved in an alcohol-related crash in the next year. Conversely, he is also predicting that 90 or more will not be involved in an A/R crash. Since it is not possible to predict which ten will be the crash-involved drivers, the chosen countermeasure program will have to be applied to all 100. This has strong implications concerning the choice of countermeasure treatment both in terms of type or severity of treatment and in terms of how many dollars can be effectively spent on a given treatment program. While the latter area is to be examined further in Chapter 4, the problem of type or severity of treatment has no "book answer." Each program administrator must make his own decision after determining what his own political system (i.e., the driving public, the legislature, and other supervisory administrators) will bear. The point, however, is that the program administrator should--and can--go into such decisions with his eyes open. Tools such as these models can provide the user with part of the necessary information.

Chapter 3

POTENTIAL COUNTERMEASURE PROGRAMS

The methodology in Chapter 2 demonstrates how to estimate a predicted probability of an A/R crash for a given individual or small group of individuals. Using these probabilities and the A/R crash severity factors, a program administrator can predict the number of fatal, injury, and PDO alcohol-related crashes in which the group of drivers will be involved during the next year. With this information the program administrator must explore potential treatment programs for the group of drivers: What countermeasure programs exist? How effectively do these treatments reduce subsequent A/R crashes? How long do they work? How much do they cost? By combining the answers to these questions with the predicted crash frequency, the administrator can perform a cost-effectiveness analysis (Chapter 4) as an aid to the decision making process.

Unfortunately, very few scientifically sound answers to these questions exist. Not as much is known about existing countermeasure programs as is needed, but because of research in community alcohol treatment programs, in ASAP's, and in other experimental efforts, some data have been obtained concerning a group of countermeasure programs. More information about these programs is being developed through research and evaluations. The purpose of this chapter is to present the state-of-the-art information concerning these countermeasures and to indicate to the manual user the programs for which estimates of effectiveness can be specified from past research, and, in contrast, the countermeasure programs for which the user must input his own estimates of effectiveness.

Many of the more familiar countermeasure programs are not included in this manual. The most obvious omissions are in the areas of enforcement and public information. Although these omissions are intentional, they should not be interpreted as implicit assessments of these types of programs. As indicated in Chapter 1, alcohol-related enforcement and public education activities are countermeasures designed for use with either the total or large portions of the driving population, and do not require prior information about which drivers should be singled out for treatment. Because the goal of this project is to better identify drivers who are at a much higher risk of A/R crash involvement than the normal driver and to treat these individuals or small groups before they are involved in a crash, the countermeasures discussed here are those which are designed for intensive use with individuals or small groups. An implied assumption, of course, is that the application of these countermeasures to an individual driver would be more effective than the application of the more general countermeasure (e.g., public education) to the same individual or small group.

The material in Chapter 3 consists of two parts: 1) a brief description of the countermeasures to be used in the methodology; and 2) a Countermeasure Table with information about each countermeasure program, including an estimate of effectiveness level, service level, and treatment costs. The following countermeasures are discussed in this chapter.

1. Warning letters
2. Driver improvement clinics
3. Hearing officer sessions
4. Probationary license for first offenders
5. Short term rehabilitation programs -

   Type 1 Alcohol Safety Schools
   Type 2 Alcohol Safety Schools
   Type 3 Alcohol Safety Schools
6. Short term rehabilitation - Power motivation training
7. Suspension or revocation of driver's license
8. Group therapy
9. Alcoholics Anonymous
10. Psychotherapy
11. Aversion therapy
12. Chemotherapy

The countermeasures are discussed in an order of progressive stringency, beginning with countermeasure activities appropriate for all drinking drivers and ending with those appropriate only for drivers with very serious drinking problems. The individual sections describe a treatment program as it has been implemented in some location and present summary information from evaluations that have been conducted. The estimated effectiveness of the program in terms of the percent reduction of alcohol-related crashes, the cost of the program, and the effectiveness period or service life of the program is included wherever possible. References at the end of each descriptive narrative have been included in case more detailed information concerning the various countermeasure programs is needed.

Following the individual narratives, Table 3.1 has been included in an attempt to summarize the information on the preceding pages for use in the subsequent economic analysis. As will be noted both in the narratives and in Table 3.1, problems exist in the attempt to specify effectiveness levels and periods for most of the eleven countermeasures. Simply stated, there continued to be troublesome gaps in our knowledge of the real effects of A/R countermeasure programs. These problems stem from two basic sources -- an inadequate evaluation of specific A/R treatment programs and the fact that certain treatments for "problem drivers" have not been specifically applied to or evaluated for alcohol-related problem drivers.

The first of these problems, the inadequacy of sound evaluations, has two parts. There are some A/R treatment programs which are so new that evaluation has not been completed. A good example of this is the use of Power Motivation Training in rehabilitation schools. Although a very sound evaluation is currently being conducted, the final results are not currently available.

However, the major part of this initial problem stems from the lack of adequately designed evaluations. Many attempts at determining effectiveness levels have been hampered by poor evaluation methods, and the resulting findings must therefore be viewed with caution. Indeed, this lack of sound research is the primary reason for the inclusion of the final manual chapter concerning evaluation methodology.

Second, there are other programs designed for and implemented with problem drivers for which good evaluations exist. Unfortunately, these programs have not been studied for the specific group of problem drivers of interest in this study -- the alcohol-related problem driver. For example, as will be seen, programs involving the use of warning letters have been studied and shown to be effective for certain subpopulations of problem drivers. Unfortunately, no studies exist in which a warning letter program has been implemented with alcohol-related problem drivers, and thus, the effectiveness levels estimated in Table 3.1 for A/R groups for this countermeasure implicitly assume carry-over of effect based on other problem driver subgroups.

Finally, it will be noted that none of the countermeasures covered are specifically designed for or have been specifically evaluated with the high-risk groups of drivers which are the basis for this manual. Thus, estimated effectiveness levels must be assumed to be valid (and equal) for all high-risk groups. Hopefully, the identification of these groups will help faster advances in the knowledge of relative effectiveness in the future.

Thus, as will be noted again in the discussion of the preceding Table 3.1, the figures provided in the Countermeasure Table must be characterized as the authors' estimates of the effectiveness levels and periods based on the best available research information. These ranges of estimated effectiveness are, of course, subject to later modification based on updated research. In review of the following narratives and in subsequent use of the Countermeasure Table, the user is urged to employ all of his local knowledge concerning treatment programs in home jurisdictions, and to stay abreast of future evaluation findings.

Even with the above noted problems, the narratives and Countermeasure Table can do the following:

1. Provide a listing of currently accepted treatments for use with alcohol-related high-risk drivers.
2. Provide current estimates of treatment costs.
3. Provide a range of estimated effectiveness levels based on the most current research knowledge to guide the user in the subsequent economic analysis.
4. Provide clear proof of the need for well-designed A/R evaluations.

I. Countermeasure: Warning Letters

II. Treatment Description:

A warning or advisory letter is the first stage of many driver improvement programs that attempt to modify the driving behavior of persons with more than their share of traffic infractions. Most states mail a warning letter when a driver accumulates three to four points within a short driving period (one to three years). The letter serves three purposes: 1) to notify drivers that there is a problem; 2) to present information on the consequences of continued negligent driving; and 3) to encourage individuals to improve their driving and thus avoid further departmental actions, such as hearings or driving suspensions.

As is indicated in the following section concerning evaluation of this countermeasure, the actual letter composition can influence its level of effectiveness for certain target groups. The most effective letter for certain groups of drivers has "low threat" wording (i.e., wording which expresses the administrator's (or hearing officer's) concern that the driver has experienced some problems and his faith that the driver's performance can improve with effort). Letters with "high threat" wording emphatically state that the driver is in trouble and threaten him with more stringent measures, such as license suspension.

III. Countermeasure Evaluation:

Studies conducted in Oregon and California have shown that warning letters have a positive effect on subsequent driving. Kaestner, Syring & Warmoth (1967) found that more drivers who received personalized letters drove without further traffic infractions than did either drivers who received the standard letter or drivers who received no letter (the control group). The personalized letter approach was reported to be most effective for drivers under 25 years old. However, this conclusion must be qualified somewhat because the control group drivers were not contacted: it was therefore not known whether their driving records reflected their actual driving performance or other factors, such as moving out of state.

A more rigorous evaluation was performed by McBryde and Peck (1970). Because the control drivers were more carefully monitored, more confidence can be placed in these results than in those of Kaestner, et al. In this study, four types of special warning letters (low threat/high intimacy, high threat/low intimacy, low threat/low initmacy, and high threat/high intimacy) were compared with the standard type of warning letter and with a control (no letter). The two low-threat letters and the standard letter were found to be effective in reducing accidents for up to seven months. The low-threat letters were found to be especially effective with female drivers and young (under 20 years old) married male drivers. Reductions in total crashes ranged from between 10 and 20 percent. The intimacy dimension (manipulated by the use of personal pronouns) did not make a significant difference. A more recent California study by Brown and Marchi (1976) again examined the effect of the warning letters in a well-designed study employing a random assignment of negligent drivers of all ages and sexes into control and treatment groups. The authors found a significant reduction in both subsequent violations and accidents between the groups. However, the size of the reduction was not as great as in the previous study, partly because of differences in methodologies. Here the data indicated a four percent reduction in subsequent accidents for a period of five months following the issuance of the letter.

In summary, the above results indicate that the warning letter should be considered a viable accident countermeasure, especially for younger drivers. Under the assumption that A/R high-risk drivers are similar to the above discussed negligent drivers, the reductions which might be expected in A/R crashes are between four and twenty percent, with the higher reductions assumed for the younger driver groups.

IV. Treatment Costs:

$0.50 - $1.50 per letter depending on the level of automation present in the implementation system.

V. References:

Brown, E., & Marchi, S. A. Post licensing control reporting and evaluation system: Implementation report. Sacramento, Calif.: California. Department of Motor Vehicles, May 1976.

Kaestner, N. F., Warmoth, E. J., and Syring, E. M. Oregon Study of Advisory Letters - The Effectiveness of Warning Letters in Driver Improvement. Traffic Safety Research Review, 1967, 11, 67-72.

McBride, R. S., and Peck, R. C. Modifying Negligent Driving Behavior Through Warning Letters. Accident Analysis & Prevention, 1970, 2, 147-174.

I. Countermeasure Program: Driver Improvement Clinics

II. Treatment Description:

Driver Improvement Clinics are usually designed for problem drivers in general, but can also be tailored for DUI drivers. The clinics are educational programs aimed at upgrading the driving performance of negligent drivers. Drivers are selected for these clinics on the basis of repeated traffic law violations or motor vehicle accidents. Typically, the drivers voluntarily participate in the clinics to either remove points from their driving record or reduce fines and sentences. Most of these programs are handled by state licensing agencies. In most cases, the clinic involves a group of drivers in a classroom situation with an instructor. However, in other instances, the clinic may involve a one-to-one student/instructor situation similar to that of a hearing.

Because the clinic classes are designed to present the information that, in the estimation of local officials, the clinic drivers need to improve their driving performance, the actual material presented varies widely from state to state. For clinic programs aimed at the general group of problem drivers, the curriculum usually includes information on the driver license point system, insurance, driver physical and mental condition as they relate to safe driving, and the punitive actions which will follow continued poor driving habits. Some state clinic programs present this material in a "high threat" manner (e.g., "you are in trouble, and if you don't improve, you will be severely punished"); "low threat" clinic programs stress defensive driving techniques to help reduce future problems.

Driver improvement clinics can also be directed at the problems of a particular subgroup of drivers (e.g., DUI offenders, or even young DUI offenders). These clinics often cover topics on the effects of alcohol on driving skills, problem drinking, and personal action.

III. Countermeasure Evaluation:

Evaluative studies indicate that the driver improvement clinic is effective in reducing subsequent convictions, but not subsequent accidents. A. S. Coppin (1961) evaluated group driver improvement meetings held in the metropolitan areas of California in late 1958 and early 1959. He found that a single group meeting of fifteen drivers who have accumulated recent violations and accidents is effective in reducing violations, that the meetings are especially effective for older drivers, and observed a significant reduction in convictions but not in accidents. However, when Marsh, Coppin, and Peck (1963) reevaluated these meetings they reported similar findings with one exception. They concluded that there was no evidence that the program is more effective for one sex or age group than for another. An even more recent study of the California negligent driver program (Brown and Marchi, 1976) examined the current Group Education Meetings (GEMs) conducted in that state. The examination of randomly assigned clinic participants and control drivers who were not to attend the clinics again indicated a significant reduction in subsequent convictions but failed to indicate a significant reduction in accidents. The authors also noted that this study of the educational clinics differed from previous studies in that attendance at the GEMs was mandatory rather than voluntary.

House and Waller (1975) evaluated the driver improvement clinics in North Carolina and found that individuals who completed the clinic fared better in terms of subsequent citations than the individuals who were assigned to the clinic but either did not attend or did not complete the course. The authors also found some indications that low-threat, defensive driving oriented lecture material appeared to be more effective for female drivers.

Henderson and Kole (1967) evaluated the New Jersey Driver Improvement Clinic, an individualized program in which each driver works with an individual instructor. They found that "fewer offenses (violations and accidents) occurred among experimentals after processing than among controls over a comparable period of time." Their data indicate a reduction in three-year accident rates of between 20 and 50 percent depending on driver age and prior driving record.

Finally, McQuire (1975), in his review of state driver improvement activities, noted that although the above mentioned "tailored" approach to driver improvement is attractive, there is no empirical evidence upon which to base assertions of either effectiveness or non-effectiveness.

IV. Treatment Costs:

Dependent on length of clinic, size of class, and curriculum used. California estimate - $10-$30/driver.

V. References:

Brown, E., & Marchi, S. A. Post licensing control reporting and evaluation system: Implementation report. Sacramento, Calif.: California Department of Motor Vehicles, May 1976.

Coppin, N. S. A controlled evaluation of Group Driver Improvement Meetings. Sacramento: State of California Division of Administration, Research and Statistics, Report #9, 1961.

Henderson, H. L., and Kole, T. New Jersey Driver Improvement Clinics: An evaluation study. Traffic Safety Research Review, pp. 100-105, 1967.

House, E. G., and Waller, P. F. Driver improvement measures: An evaluation based on conviction and crash records. Chapel Hill: University of North Carolina Highway Safety Research Center, 1975.

Marsh, W. C., Coppin, R. S., and Peck, R. C. A reevaluation of group driver improvement meetings. Highway Research Record, 163: 120-131, 1967.

McQuire, J. P., et al. State driver improvement analysis: Volume II. Sunnyvale: Public Systems Incorporated, 1975.

I. Countermeasure: Hearings

II. Treatment Description:

The hearing is used by state licensing agencies to attempt to improve or control the driving performances of negligent drivers (individuals with accumulated traffic convictions and/or repeated accidents). The hearing is a face-to-face meeting between a driver improvement analyst or counselor and the problem driver. The dual purpose of the hearing is to stress the importance of driving safely and to discuss the consequences of additional violations and collisions.

Typically, a hearing is conducted in a conversational format. The hearing officer attempts to identify and analyze the driver's problems and to provide suggestions for correcting them. At the end of the hearing, the driver is usually told he will receive a letter from DMV containing the department's decision on the case (e.g., probation and license suspension or revocation). In some states, the driver may be given the option of attending a driver improvement clinic to reduce points or to shorten or prevent suspension.

III. Countermeasure Evaluation:

House and Waller (1976) evaluated the driver improvement program in North Carolina, including an evaluation of the combined clinic and hearing experience. They found that "differences between groups of drivers failing to attend a meeting with a hearing officer, or failing to even respond to the advisory letter, and the corresponding groups attending the meeting and then completing the clinic were not great and in some cases favored the failed-to-attend group." They caution that there were many biases in the analysis (e.g., a greater percentage of the failed-to-attend group received a suspension or revocation of their driving privilege).

Coppin, Peck, Lew and Marsh (1965) conducted an evaluation of the hearing process of the California DMV. Two groups of problem drivers were selected, one to be used as the control group and one to be scheduled for hearings. The hearing group was divided into those who appeared, those who did not appear, and those who could not be contacted by mail. Analysis of the driving records for the subsequent two years indicated: (1) the hearing group had significantly fewer citations than the control group for the first year but not for the second year; (2) no significant differences between the two groups with respect to accidents in either of the two years; and (3) within the hearing groups, no significant differences in the subsequent citation and accident frequencies between those who appeared at the hearing and those who did not appear. The authors concluded that receiving the hearing notice is an important source of the hearing program's effectiveness, apart from the actual face-to-face contact with a hearing officer.

The Wisconsin DMV (1969) reported that interviews had a positive effect in reducing the percentage of drivers who had accidents. However, Goldstein (1974), in his re-analysis of these data, reported that the interview group had a higher mean number of accidents. Goldstein contended that the Wisconsin study was contaminated by selection biases such as unequal exposure periods for the experimental and control groups in the subsequent treatment period.

In contrast to the above finding, Brown and Marchi (1976) found that current California hearings for negligent drivers significantly reduce both subsequent convictions and accidents. As noted previously, the authors randomly assigned negligent drivers who would be eligible for a hearing into both treatment and control groups and monitored the subsequent driving records. The results of this well-designed evaluation indicated a 17 percent reduction in accidents for approximately eight months following the hearing. This particular hearing process was used with middle to upper range negligent drivers--drivers who would have already passed through the warning letter and educational clinic stages. The authors also examined an additional hearing further along the negligent driver treatment spectrum--the probation violation hearing. This treatment would, by definition, only affect the "hard core" negligent drivers, those drivers who have passed through all other treatment and who continue to have problems. As might be expected, the associated accident reductions are somewhat smaller than in the previous hearing. Here, the data indicated a statistically significant reduction in accidents of nine percent, and an effectiveness period of seven months.

In summary, evaluations of the effects of individual hearings have ranged from the pessimistic (i.e., no effectiveness) to moderately effective (i.e., 9-17 percent reduction in crashes). It would appear that the success of the hearing process may be related to both the nature of the hearing and to the level of problems exhibited by the subjects. The recent Brown and Marchi study, involving middle to upper range negligent drivers who had already undergone other treatments, indicate that such hearings might be assumed to be somewhat effective for persons within the A/R high-risk groups who have exhibited a history of repeated problems (e.g., the High Violation Group or the higher risk subpopulations within other groups) or persons who continue to have problems after receiving some other less stringent form of treatment. While none of the evaluations specifically examined A/R negligent drivers, an estimated range of effectiveness of 0-15 percent is assumed for A/R crashes.

IV. Treatment Costs:

$30 - $100 per driver, depending upon the program.

V. References:

Brown, E., & Marchi, S. A. Post licensing control reporting and evaluation system: Implementation report. Sacramento, Calif.: California Department of Motor Vehicles, May 1976.

Coppin, R. S., Peck, R. C., Lew, A., & Marsh, W. C. The Effectiveness of Short Individual Driver Improvement Sessions. Sacramento: State of California Department of Motor Vehicles, 1965.

Goldstein, L. G. Driver Improvement: A Review of Research Literature. California Traffic Safety Education Task Force, Department of Education, 1974.

House, E. G., and Waller, P. F. Driver Improvement Measures: An Evaluation Based on Conviction and Crash Records. Chapel Hill: University of North Carolina Highway Safety Research Center, 1976.

Wisconsin Division of Motor Vehicles. Wisconsin's Driver Improvement Program: Information on What It Is and How Effective It Has Been. Madison: Author, 1969.

I. Countermeasure: Probationary License for DUI First Offenders

II. Treatment Description:

A serious problem in the implementation of alcohol-related countermeasures is that the DUI violation-conviction rate is much lower than that of other violations. Indeed, many original DUI citations are reduced to reckless driving violations under the hypothesis that any conviction is better than none at all. The low conviction rate is thought to be based on the reluctance of jurors to convict an individual because of the hardship of license revocation. To reduce this reluctance, several states have implemented a limited license concept.

The limited license concept provides the court with the option of granting a limited driving privilege to some individuals convicted of their first DUI offense. The limited driving concept punishes the illegal act of drunk driving while taking cognizance of the need to drive. Under this limited privilege, the convicted offender is issued a special license restricting driving to specific times and/or places (e.g., to and from work, between 8 a.m. and 5 p.m.). If the driver is caught violating these provisions, the license is usually suspended, just as it would have been following conviction without the privilege. This limited privilege is usually offered only to first offenders since there is some evidence that persons with more than one DUI conviction have serious drinking problems.

III. Countermeasure Evaluation:

In a study of the North Carolina version of the limited license concept, Johns and Pascarella (1971) examined the law's effectiveness in terms of whether it (1) resulted in an increase in the number of DUI convictions and a decrease in DUI charges amended to reckless driving and (2) whether it resulted in a reduction in the limited licensed driver's accident and violation rates. The authors found that the rate of first offender DUI convictions increased by 18.3 percent and that the rate of DUI citations that were amended to reckless driving convictions decreased. They also found that the subsequent accident records of the limited driving license recipients were better than those of the amended group and no worse than those of average

North Carolina drivers. The limited driving concept proved to be particularly effective for drivers between the ages of sixteen and twenty-five and for drivers over the age of forty-six. Limited privilege drivers between the ages of twenty-six and forty-five showed a higher accident rate than a random sample group. The small sample size of the limited license group, however, reduces the confidence in these conclusions, particularly when violation and accident rates are examined. Based on the decreases in amended charges and the accident rate differences between the amended group and the DUI group, an overall percentage reduction in total crashes of between 6 and 12 percent is indicated. Since this countermeasure is specific to A/R high-risk drivers, a similar reduction in A/R crashes might be assumed. In fact the reduction in A/R crashes might be slightly greater than for total crashes since the probationary license is designed to keep the drinking driver off the road in high-risk drinking/driving periods (e.g., no late night driving).

IV. Treatment Cost:

Implementation costs are almost non-existent because many states provide judges with driving records prior to sentencing. Additionally, many Motor Vehicle Departments already have existing systems for limiting the driver privileges (i.e., restrictions and learning permits). The cost estimates must be made by the user.

V. Reference:

Johns, T. R., and Pascarella, E. A. An assessment of the limited driving license amendment to the North Carolina statutes related to drunk driving. Chapel Hill: University of North Carolina Highway Safety Research Center, 1971.

I. <u>Countermeasure</u>: Short Term Rehabilitation (STR) Programs -
Type 1 Alcohol Safety Schools
Type 2 Alcohol Safety Schools
Type 3 Alcohol Safety Schools

II. <u>Treatment Description</u>:

Various short-term treatment programs have been used in past ASAP efforts. General information concerning STR activities is followed by a more specific description of three common types of alcohol safety schools. Power Motivation Training is described in a separate section.

Short Term Rehabilitation is a generic term for programs developed for use in the Alcohol Safety Action Projects (ASAPs) to aid drivers with drinking problems in their transition between the courts and the community resources. As its name implies, the STR programs are shorter in length (when compared to chemotherapy or psychotherapy) and are often group-oriented. Because of the large number of people (all convicted DUI's) involved in this phase of rehabilitation, the courts act only as referral agents for the community treatment centers, which are more capable of supporting the longer types of treatment. In an attempt to evaluate ASAP activities, Nichols and Reis (1974) visited 27 ASAP sites and identified 76 STR programs in use. These programs were classified into three basic groups based on organizational factors such as amount of information presented, participant-leader interaction, and average session size. These basic types are described below.

<u>Type 1 alcohol safety schools</u>: Type 1 schools are more oriented towards group therapy activities. Class time is split between instructor lectures and student participation and interaction. The students have ample opportunities to interact with the leader as well as with other participants. Total program time averages 18 hours and 15 participants is a typical size for these Type 1 schools.

<u>Type 2 alcohol safety schools</u>: Type 2 schools spend approximately 3/4 of their program time in information transmission or lecture sessions. When compared to the Type 1 schools, participants of Type 2 schools have less opportunity to interact with other participants although they have the same amount of interaction with the leader. The average program time here is 11 hours and the average group size is about 20 participants.

Type 3 alcohol safety schools: Type 3 schools, as direct opposites to the Type 1 schools, engage in activities that are mostly related to information transmission. In this regard, they are most closely akin to Driver Improvement Clinics. Very little program time is spent in participant-leader interaction, with practically no time spent in participant-participant interaction. This type of school also is the shortest (eight hours) and has the largest number of participants (average around 47).

The material presented and discussed in the schools varies widely, but most programs include information on the consequences of drinking on the physiological skills associated with driving, individual differences in tolerance to alcohol, reasons for drinking and driving, self-recognition of an alcohol problem, and the effects of alcohol on other aspects of the subject's life.

III. Countermeasure Evaluation:

Evaluations of alcohol safety schools conducted before Nichol and Reis (1974) found positive results only in knowledge gain and attitude change. There were practically no reductions reported in violations or in crashes among the few controlled studies performed at this stage (Smart, 1970).

Because of inadequate evaluation procedures, several revisions were made and a better evaluation model was proposed. This became the focus of the Nichols and Reis (1974) study.

After classifying the alcohol safety schools the authors compared the rate of recidivism (rate of rearrest for alcohol-related offenses after entering an alcohol safety school) among the three school types and for each type of driver (problem drinker and non-problem drinker). Recidivism was chosen as the criterion measure of effectiveness because it is 36 times more frequent than subsequent fatal crashes for the population under study (convicted DUI's). Based on various data analyses, the authors found no differential effectiveness (as measured by the rate of recidivism) among the three school types. However, no conclusion as to the overall effectiveness of the alcohol safety school program could be drawn because no control group was used for this study and thus no comparisons of treated and untreated drivers could be made. In addition, the study is impaired by two other limitations. First, since random assignment was not used, there may be bias between assignment procedures and school types. For example, if subjects with the worst records were assigned to the "best" school type, this could substantially dilute that treatment effect. Second, despite the frequency of recidivism, it might not have been sensitive enough to detect subtle differences among the different school types. Based on these difficulties, the authors strongly recommended that future attempts at evaluation include the random assignment of subjects to treatment and control (no treatment) groups and the careful selection of the criterion to be measured.

These recommendations are being followed in an ongoing STR evaluation program funded by NHTSA. This program is currently being carried out at eleven ASAP sites across the nation. In this study, convicted DUI's are first screened to determine the extent of their drinking problem. Those who have been diagnosed as midrange problem drinkers (i.e., between the social drinker and the alcoholic) are further screened to exclude those with serious health problems and visible psychopathy. The remaining group of midrange problem drinkers forms a candidate pool from which subjects are randomly assigned to each of the four basic groups: Alcohol Safety School, Power Motivation Training, Group Therapy, and Control. In addition, many of the sites used differing combinations of these three basic treatments. Both driving and nondriving (changes in health, job and marital status) behavior criteria are being measured at 6, 12, and 18-month intervals to obtain various measures of program effectiveness. Although some minor problems have arisen in implementation of the design, this may well be the most sound evaluation conducted in the alcohol area. While the final report concerning effectiveness cannot be published until early 1979, an interim report by Struckman-Johnson, Ellingstad, and Strawn (1978) covers the initial analysis of the data from the first 12 months. One initial finding from questionnaire and interview data concerns the fact that the drivers involved in the study may be more similar to normal social drinkers than was originally anticipated, i.e., they may be slightly lower on the scale than "midrange problem." This point is of importance both in terms of possible "room for improvement" due to the treatment (there being less potential capacity for change among social or near social drinkers than among the problem drinkers) and in terms of the applicability to the high-risk groups identified in this user manual. At least from these preliminary data, it appears that findings from this study may apply to a broader range of drinker/driver than originally anticipated.

The alcohol schools under study fall within all three of the above listed types, with total treatment time ranging from 4 to 12.5 hours. Based on an analysis of covariance and a survival-rate analysis, the authors conclude that, even though the results are somewhat puzzling, there is some evidence of Alcohol Safety School effectiveness in changing drinking/problem-driving patterns. The effect appears to have diminished since the initial 6-month after treatment analyses. Although total crashes are slightly lower for the treatment groups, the difference is highly non-significant ($p = .48$).

Thus, in summary, there is as yet little conclusive evidence of Alcohol Safety School effectiveness in reducing subsequent A/R crashes. However, because of the above-noted indication of effectiveness and the fact that this well-designed evaluation hasn't yet been completed, no estimate of effectiveness will be made at present.

IV. Treatment Cost:

Estimated to be $10 - $70/student, depending on school type.

V. References:

Boyatzis, R. Breaking the power of alcohol. Boston: McBer & Co., June, 1974.

Nichols, J., & Reis, R. One model for the evaluation of ASAP rehabilitation effort. NHTSA Technical Report, DOT HS-801 244, October, 1974.

Smart, R. G. The evaluation of alcoholism treatment programs. Addictions, 1970, 17(1), 41-51.

Struckman-Johnson, D. L., Ellingstad, V.S., and Strawn, V. L. Interim Analysis of STR Effectiveness. NHTSA Technical Report, DOT HS-803 285, January, 1978.

I. Countermeasure Program: Short-Term Rehabilitation--Power Motivation Training

II. Treatment Description:

Power Motivation Training is an experimental short-term (approximately 30 hours of sessions) rehabilitation program aimed at the midrange problem drinker. The treatment, an alternative to more traditional group therapy, attempts to help people to understand how thoughts of power are related to abusive drinking. The program also teaches people to identify the times when they feel powerless and then provides them with ample opportunities to experiment with ways other than drinking (relaxation exercises, athletics, prayer, reconceptualization of interpersonal confrontation as win/win rather than win/lose discussions, etc.) to cope with this feeling. Once the new behavior is learned, it is reinforced by the group until the person feels confident that it can fulfill his power concerns. In order for the new behavior to serve as a functional substitute for drinking, it must be easily accessible and provide a relief similar to the one previously provided by drinking. The PMT program would be assumed to work best with men, because they tend to drink for power more often than women, who often drink to compensate for feelings of loneliness or failure.

III. Countermeasure Evaluation:

As noted above, PMT is a new, experimental program. Unlike many other treatments, the program is currently being evaluated in the rigorous design discussed in the preceding section concerning STR Alcohol Safety Schools. As indicated there, PMT is one of the basic treatments to which midrange problem drinkers have been randomly assigned. Because of interest in this newer type of treatment, PMT was used at seven of the eleven sites either alone or in combination with other treatments.

Somewhat in contrast to the STR Alcohol Safety School, the preliminary analysis of the 12 month data have led the authors to draw the tentative conclusion that, at best, PMT has shown no positive effects on drinking or drinking/driving behaviors. Indeed, there appears to be some indication that PMT has a negative effect on survival time (i.e., time to first A/R rearrest) in that the control group had higher survival rates than the treatment groups. When the PMT plus Alcohol Safety School treatment combination was examined, the effect was again somewhat confusing. Although total accidents were significantly lower for the Treatment Group (by 52 percent), total traffic offense arrests and two other measures of drinking behaviors were significantly higher for the Treatment Group. In the author's opinion, while it is not yet possible to firmly conclude that PMT is exhibiting a negative effect on drinking and driving behaviors, there is even less evidence that the treatment is having any positive effect at all.

In summary, while preliminary indications are that PMT would have to be estimated as non-effective, the continuing analyses of the STR data should be monitored by the user.

IV. Treatment Costs: $70 - $160/subject (with 50-75 percent usually paid by subject)

V. References:

Boyatzis, R. Breaking the power of alcohol. Boston: McBer & Co., June, 1974.

Nichols, J. and Reis, R. One model for the evaluation of ASAP rehabilitation efforts. NHTSA Technical Report, DOT HS-801 244, October, 1974.

Struckman-Johnson, D. L., Ellingstad, V. S., and Strawn, V. L. Interim Analysis of STR Effectiveness. NHTSA Technical Report, DOT HS-803 285, January, 1978.

I. Countermeasure Program: Suspension or Revocation of Drivers License

II. Treatment Description:

Most, if not all, states have a law making it mandatory to suspend or revoke the driving privileges of a driver who has been convicted of one or more driving under the influence (DUI) offenses. The rationale behind this type of countermeasure seems, at first glance, to be simple and effective. The basic premise is that by removing the driving privileges of a DUI offender, this person will be kept off the road and thus prohibited from operating a motor vehicle while under the influence of alcohol.

A person who is convicted of DUI may have his driver's license either suspended or revoked. Suspension means that a person's privilege to drive is temporarily withdrawn. The withdrawn license is returned at the end of the suspension period unless it has expired. If it has expired, the offender may apply for a renewal license. Revocation, on the other hand, means that the person's privilege to drive a motor vehicle is terminated. At the end of the revocation period (usually longer than that associated with a suspension) the person must apply for a new license as if he/she were applying for it the first time, a situation which often requires a road test along with the usual written and vision tests.

III. Countermeasure Evaluation:

Most studies relating to suspension/revocation deal with evaluations of the effectiveness of this countermeasure for all types of driving offenses rather than focusing solely on DUI offenders. Thus, the effectiveness of these programs when applied to DUI offenders is somewhat difficult to determine.

A 1965 study by Coppin and Oldenbeek which looked at the driver record files of 1,326 suspended or revoked negligent drivers in California found that of these drivers, 47 percent of the males and 33 percent of the females had at least one recorded conviction or accident during their period of suspension/revocation. While the recordsof these suspended/revoked drivers were not compared to their prior records or to control group, and thus no inferences concerning effectiveness are possible, the study does provide a conservative estimate that at least 47 percent of the males and 33 percent of the females suspended or revoked drivers continued to drive after this action had been taken.

In an Oregon study, Kaestner and Speight (1974) compared the relative effectiveness of discretionary suspension compared to the effects of a warning letter, a probationary license, and a National Safety Council defensive driving course. Drivers in these four different treatment groups were also compared to a group of drivers who were eligible for suspension but for whom no action was taken--a control group. When the proportion of drivers who were able to drive for a full year without either a moving traffic violation or chargeable accident was examined for the four groups, the suspended group was better than the warning letter group, but was no different from the no action control group. Both the probationary license and defensive driving course groups had better subsequent driving records than did the suspension group.

In a 1976 study, Li and Waller attempted to determine the effectiveness of a habitual offender (HO) statute passed by the North Carolina legislature which became effective in June, 1969. This long-term revocation program is concerned with repeated traffic offenders. Under the provisions of the statute, drivers who accumulate 12 moving violations, each of which would authorize a 30 day discretionary suspension, or three major violations within a seven-year period are declared habitual offenders and are eligible for a five-year revocation. For the 6987 drivers identified as being HO's, alcohol violations were the second most frequent type of violation (30 percent of the total violations) for which drivers became eligible for HO status. An examination of the driving records of HO's for two years following their referral to the courts indicated that these revoked drivers had more violations but fewer accidents than other adult drivers in North Carolina. The authors feel that the lower accident rate may be due to underreporting of accidents by HO's already in trouble with the courts. Due to differences in court districts in implementing the HO statute, the authors were able to compare the driving records of confirmed HO's and pending (eligible but not confirmed) HO's. If the statute is an effective countermeasure, it would be expected that the confirmed group would have better driving records than those pending disposition. In this analysis, no significant differences were found between the two groups, thus questioning the effectiveness of long-term revocation as an appropriate countermeasure device for highly negligent drivers.

A 1977 study by Hagen dealt specifically with multiple DUI offenders. A group of drivers who had their licenses suspended or revoked for multiple DUI convictions (a mandatory rather than discretionary suspension) was compared to a matched group of drivers who avoided suspension by having prior DUI convictions declared unconstitutional. The analysis indicated statistically significant differences in subsequent driving records for the two groups with the suspended drivers experiencing approximately 35 percent fewer total crashes and 29 percent fewer A/R crashes, the latter difference not being suitable for statistical testing. It was established that the treatment effect lasted for over three years after initial suspension. Hagen also noted significant age differences in the effectiveness of suspension in that the over 30 group had significant mean crash rate reductions while the two groups (suspended and not-suspended) of younger drivers did not. It was interesting to note that even though the crash rate differences exhibited in the younger age group were not significant (or underlying assumptions necessary for the statistical test were not met), even for this group, the reduction in total crash rate was 30 percent, A/R crash rate was 33 percent, and injury/fatal crash rate was 37 percent. While these differences were, in general, slightly lower than for the two older age groups, they were still quite large. It is also noted that while the control group in this study was "self-chosen" (i.e., those who had earlier convictions deemed unconstitutional) and thus other underlying group factors (e.g., exposure, risk taking propensities) could account for some of the measured difference, the author's choice of control variables for use in the covariate analysis appears to have accounted for many of the possible intervening factors.

In summary, the studies to data appear to indicate that mandatory (rather than discretionary) suspension/revocation can have an effect on subsequent driving behavior. Primarily based on the Hagen study, which is directly related to DUI offenders, it is estimated that the effectiveness in reducing A/R crashes ranges from 25-35 percent, with the higher reductions more applicable to older driver subgroups.

IV. Treatment Costs:

Unknown--would include DMV administrative costs and certain court related costs. Probably low compared to other countermeasures.

V. References:

Coppin, R. S., and Van Oldenbeek, G. "Drivers Under Suspension and Revocation." Sacramento: California Department of Motor Vehicles, 1965.

Hagen, R. E. "Effectiveness of License Suspension or Revocation for Drivers Convicted of Multiple Driving-Under-the-Influence Offenses." State of California: Department of Motor Vehicles. Report #59, September, 1977.

Kaestner, N. F. and Speight, L. Oregon Study of Driver License Suspensions. Salem: Oregon Department of Transportation, Motor Vehicles Division, April, 1974.

Li, L. K., and Waller, P. F. Evaluation of the North Carolina Habitual Offender Law. Chapel Hill: University of North Carolina Highway Safety Research Center, March, 1976.

I. Countermeasure: Group Therapy

II. Treatment Description:

Group therapy sessions are designed for both midrange problem drinkers and for alcoholics. Group therapy may be either a short or long-term treatment program, depending usually on the availability of funds and the mechanics of administration. Group therapy began receiving increasing interest and use during and after World War II. The treatment program is a response to the prohibitive cost and the scarcity of trained professionals available to provide individual therapy. The emphasis in this type of therapy is placed on the individual's gaining insight into his own needs and actions, interaction among group members, and developing positive behavioral patterns. With direction of a group leader and cooperation and support of other group members, participants discuss the problems they are facing. Characteristically, drinking, jobs, and families are initially discussed with more sensitive topics including feelings of anger, resentment, guilt, distrust, loneliness, depression, fear, inferiority, and worthlessness coming up after the understanding and support of group members have been established.

The choice and training of group leaders is one of the keys to successful treatment. Although skilled professionals probably do the most effective job of leading a group, the cost of this caliber of direction is quite high--approximately $10 per subject per session. Trained paraprofessionals often perform quite well in this capacity, at a much lower cost--about $3 per subject per session. Studies have shown that an effective compromise can be reached by using experienced paraprofessionals under the supervision of certified professionals. The group should include no more than 15 participants in order to provide the opportunity for effective personal involvement. Meetings should be scheduled so that there is minimal job and family interference. Two-hour week-night sessions, with the participants having an opportunity to express a preference for a particular evening, have resulted in satisfactory schedules for many groups.

III. Countermeasure Evaluation:

Although many professionals consider long-term group therapy to be the most effective treatment of alcoholics (other than Alcoholics Anonymous), little is known about the true effectiveness of these programs in reducing subsequent traffic accidents. In addition, as noted by Sackman (1972), because of cost considerations, public programs involving this treatment must necessarily be short, high-impact sessions conducted over the course of weeks rather than months. The inclusion of group therapy sessions as a treatment at six sites in the previously discussed ongoing evaluation of STR programs (Struckman-Johnson, et al.,:1978) may mean that effectiveness levels will be quantified by 1979. However, in the project's 12- month interim report, the authors provided information only on the treatment's content and did not examine the effects of group therapy.

IV. Treatment Costs:

$10/session/subject for trained professionals as leaders. If paraprofessionals are cited, the cost may range from $3 to $7 per session per subject.

V. References:

Fox, R. A multidisciplinary approach to the treatment of alcoholism. International Journal of Psychiatry. January 1968, 5 (1), 34-44.

Sackman, H. Guidelines for developing and implementing community programs to assist and reeducate drinking drivers. Washington, D.C.: U.S. Department of Transportation, National Highway Traffic Safety Administration, 1972.

Struckman-Johnson, D. L., Ellingstad, V. S., and Strawn, V. L. Interim Analysis of STR Effectiveness. NHTSA Technical Report, DOT HS-803 285, January 1978.

I. Countermeasure Program: Alcoholics Anonymous

II. Treatment Description:

Alcoholics Anonymous (A.A.) is an international fellowship of self-admitted alcoholics who help each other to achieve and maintain sobriety. The emphasis is on sharing experiences, strength, and understanding. Any person who thinks he has a drinking problem can be a member of Alcoholics Anonymous. The basic unit of A.A. is the local group which,is self-supporting and autonomous. There are currently over 18,000 local groups in 92 countries. The core of the A.A. program of personal recovery is the "Twelve Steps," the first of which is the acceptance that alcohol has made the life of the alcoholic unmanageable. The "Twelve Traditions" are suggested principles for relationships with fellow A.A. members and the community. Each member of A.A. concentrates on the "Twenty-Four Hour Plan" - staying sober for the next twenty-four hours.

III. Countermeasure Evaluation:

In 1967 the American Medical Association stated that Alcoholics Anonymous is the most effective means of treating alcoholism. In a survey conducted by A.A., 64 percent of the 11,355 respondents reported maintaining abstinence for one to twenty years after their first A.A. meeting or their first A.A. year. No follow-up study of the nonrespondents was conducted. Ditman, et al., (1967) conducted an evaluation attempting to compare A.A. with a psychiatrically-oriented clinic treatment program and a control group receiving no treatment. The clinic program, earlier evaluated by Davis and Ditman (1963), employed various traditional psychiatric techniques, but concentrated on group psychotherapy and such medication as Antabuse. Alcoholics seeking treatment at the clinics include court-referred alcoholics as well as self-referred alcoholics. In the 1967 study, the three groups were all composed of chronic drunk offenders--persons with either two drunk arrests in the previous three months or three drunk arrests in the previous year. Each offender was given a $25 fine and a 30-day sentence suspended to one year probation. The offenders were then randomly assigned to one of the three treatment groups, and told to report back to court with proof of compliance in six months. When the arrest record of each offender was followed for at least one year after conviction, no significant difference between the three treatments was found. The authors note that the control sample could not be considered a "no treatment" group in that they were fined and put on probation.

Based on the studies reported, a range of effectiveness is difficult to estimate. While the AMA questionnaire study indicates very positive results for volunteer subjects, the 1967 Ditman study indicates no difference between the effectiveness of Alcoholics Anonymous and probation for court-assigned subjects, a situtation somewhat closer to conditions in which this user manual methodology might be applied. While no studies were reviewed concerning the effectiveness of probation on the A/R crashes of problem drinkers, it might be assumed that such a countermeasure would fall below the 6-12 percent effectiveness level estimated for the probationary license treatment for first offenders that was discussed earlier. Based on this rather "pessimistic" level and the "optimistic" level provided by the AMA, it might be estimated that the level of effectiveness for A.A. falls between 2 and 40 percent, depending on whether the treatment is voluntary or assigned.

IV. Treatment Costs: Unknown

V. References:

Alcoholics Anonymous. 44 Questions. 1952.

Alcoholics Anonymous. If you are a professional A.A. wants to work with you. 1972.

Davis, F. M., and Ditman, K. S. The effect of court referral and disulfiram on motivation of alcoholics: A preliminary report. Quarterly Journal of Studies on Alcohol, 1963, 24 (2), 276-279.

Ditman, K. S., Crawford, G. G., Forgy, E. W., Moskowitz, H., and MacAndrew, C. A. Controlled experiment on the use of court probation for drunk arrests. American Journal of Psychiatry, 1967, 124 (2), 160-163.

I. Countermeasure: Psychotherapy

II. Treatment Description:

The term psychotherapy, as related to treatment of alcoholics, refers to a program in which a trained specialist interacts with a patient in a series of private, face-to-face, sessions. Thus, it is similar to group therapy programs except that the group is limited to one therapist and one participant. This treatment has been used in many locations with alcohol offenders placed on probation by the courts. Almost all of these offenders insist they are not alcoholics, deny any serious emotional problems, and therefore, lack motivation for treatment. Margolis and Krystal (1964) describe a program implemented in Detroit. In the sessions, the therapists attempted to dissociate themselves from the court and to establish a supportive therapeutic role. Interviews with the patient and his family were conducted by a social worker, the patient was examined psychiatrically, and a battery of tests were administered by a psychologist. In the initial therapy session, the patient was confronted with the results of the interviews and examinations, and with evidence to show he was an alcoholic. Major efforts were made by the therapists to win the patient's confidence and trust. Family therapy was used extensively in all cases and the involvement of relatives, employers and the other professionals was felt to be a key feature of the approach.

III. Countermeasure Effectiveness:

Hill and Blane (1967) cite a review from 1941 which concluded that the psychiatric profession, at that time, was unable to make any sort of conclusions about the usefulness of psychotherapy in the treatment of alcoholism. Of even more interest, and of particular pertinence for the present, is the fact that Hill and Blane not only draw the same conclusion 25 years later, but also reinforce it. The basic problem in any attempt to assess the utility and efficacy of psychotherapy lies in the lack of comparability in the reported studies in this area.

IV. Treatment Costs: Unknown

V. References:

Hill, M. J., and Blanc, H. T. Evaluation of psychotherapy with alcoholics. Quarterly Journal of Studies on Alcohol, 1967, 28, 76-104.

Joscelyn, K. B., Maichel, R. P., and Goldenbaum, D. M. The drinking driver: A survey of the literature. Volume I. Court Procedures Survey. Bloomington, Indiana: Institute for Research and Public Safety, 1971.

Margolis, M., Krystal, H., and Siegel, S. Psychotherapy with alcoholic offenders. Quarterly Journal of Studies on Alcohol, 1964, 25, 85-99.

I. Countermeasure: Aversion Therapy

II. Treatment Description:

Aversion therapy consists of training the individual to associate something, such as sight, smell or taste of an alcoholic beverage, with an unpleasant reaction. Some of the unpleasant reactions which have been used are nausea and vomiting, pain due to electric shock, and muscle paralysis. The treatment consists of causing one of these unpleasant reactions to happen when alcohol is presented to the patient. After several repetitions of pairing this unpleasant reaction with alcohol, the patient is conditioned--the sight or smell of alcohol causes him to recall the noxious stimulus. Thus, he reduces or eliminates his drinking.

III. Countermeasure Evaluation:

Aversion therapy involving the use of drugs which induce vomiting has been used on several thousand alcoholic patients with varying reports of success. In a study of over 4,000 alcoholic patients over a 13-year period, follow-up data indicate that 60 percent remained abstinent for at least one year, 51 percent for at least 2 years, 38 percent for at least 5 years, and 23 percent for at least 10 years after their first treatment. The type of patient best suited for this treatment is probably the "essentially normal, stable person who has gradually developed the habit until it has gotten the best of him, and now wants help in breaking the habit and is willing and anxious to stop drinking for good" (Joscelyn, et al., 1971). When aversion therapy is compared with Antabuse and group hypnotherapy, using the same type patient and the same institutional setting, it was found to be the least effective, with only 24 percent improvement.

There is some question as to the duration of effectiveness of a single set of therapy sessions. Repeated sessions at regular intervals (3-5 years) may be needed for best results.

Based on the findings of the studies reviewed and on the reported need to choose the proper type of subject, a range of A/R crash reduction effectiveness of 10-40 percent would be estimated for alcoholics treated by this method.

IV. Treatment Costs: Unknown

V. References:

Joscelyn, K. B., Maichel, R. P., & Goldenbaum, D. M. The drinking driver: A survey of the literature. Court Procedures Survey: Reference Volume I. Bloomington, Indiana: Institute for Research and Public Safety, 1971.

Margolis, M., Krystal, H., & Seigel, S. Psychotherapy with alcoholic offenders. Quarterly Journal of Studies on Alcohol, 1964, 25, 85-99.

I. Countermeasure: Direct Chemotherapy (Antabuse)

II. Treatment Description:

Direct chemotherapy, usually involves the use of the drug Antabuse (disulfiram) to induce an unpleasant reaction in persons who drink alcohol while on the drug. Used in the treatment of alcoholics, it can be considered a form of aversion therapy in which the conditioning agent is actually present in the patient's body in the form of a medication which interferes with the metabolism of alcohol so that even one drink will cause a toxic reaction of a shock-like nature. The disulfiram pill is taken daily for an indefinite period of time; the effect of each pill lasts four days. If the alcoholic drinks, the reaction lasts from two to four hours and is characterized by lobster-red coloring of the upper body, pounding headache, coughing, nausea, and elevated blood pressure. In addition, side effects and some severe toxic reactions have been reported. Most patients should remain on the drug for at least two years while undergoing psychotherapy or attending sessions of alcoholics anonymous.

III. Countermeasure Evaluation:

Attempting to evaluate the effectiveness of antabuse in court or non-court treatment programs, researchers have encountered several problems, including improper evaluation criteria, insufficient study period, lack of experimental controls, inadequate selection of subjects, and lack of follow-up studies. As noted in literature reviews, these problems explain why the claims of "recovery" rates for disulfiram range from 35 to 80 percent.

As was indicated in the discussion of Alcoholics Anonymous, the 1967 Ditman, et al., study in which chronic drunk offenders were randomly assigned to A.A., probation (no treatment), or a psychiatrically-oriented clinic which employed medication such as Antabuse indicated no difference between the subsequent rearrest records of the three groups.

Because of these evaluation problems and because effective use requires proper diagnostic choice of the subject, a range of effectiveness of 2-50 percent is assumed for alcoholics so treated by this method.

IV. Treatment Costs: $150 - $200/person/year

V. References:

Chafetz, M. E. Days in the treatment of alcoholism, Medical Clinics of North America, 51: pp. 1249-1259, September, 1967.

Ditman, K. S. Evaluation of drugs in the treatment of alcoholics. Quarterly Journal of Studies on Alcohol, Supp. No. 1, pp. 107-116, 1961.

Ditman, K. S., Crawford, G. G., Forger, E. W., Moskowitz, H., & McAndrew, C. A. Controlled experiment on the use of court probation for drunk arrests. American Journal of Psychiatry, 1967, 124 (2), 160-163.

Fox, R. A multidisciplinary approach to the treatment of alcoholism. International Journal of Psychiatry, January, 1968, 5 (1), 34-44.

Joscelyn, K. B., Maichel, R. P., & Goldenbaum, D. M. The drinking driver: A survey of the literature. Court Procedures Survey: Reference Volume I. Bloomington, Indiana: Institute for Research and Public Safety, 1971.

The Countermeasure Table

The following table summarizes some of the information presented in the previous pages. In order for the program administrator to complete the cost effectiveness methodology presented in the next chapter, he will need to estimate the three factors used in the cost effectiveness model for each countermeasure analyzed. The three factors are: 1) program effectiveness, 2) program cost, and 3) effectiveness period. These three terms, keys to the implementation of the cost effectiveness methodology, are defined below:

1. Program effectiveness factors for each level of crash severity are to be calculated from the estimated A/R crash reduction percentage shown in columns 7 through 9. The percentages in these columns represent the estimated ranges of percent reduction in subsequent A/R crashes that might be expected from application of a specific countermeasure program. Three percentage reductions are presented--1) a fatal accident reduction, 2) an injury accident reduction, and 3) a PDO accident reduction. While all percentages in the table are equal across severity levels for a given countermeasure, there may well be treatment programs which differentially affect the A/R crash severities. For this reason, three reduction factors are included in the later cost effectiveness methodology.
2. Treatment cost estimates are presented in column 10. These figures represent the estimated cost per person of implementing a countermeasure program. This information is based on research reports and on estimates made by alcohol safety program personnel at both state and federal levels. If the manual user has developed better cost data in his own jurisdiction, they should be used. The figures presented in the table are a guide for those alcohol program administrators who have not developed their own cost information. The user should also note that in some cases part of the treatment cost can be defrayed by charging the subjects themselves. Thus, while these charges continue to be societal costs, they no longer must be taken directly from the administrator's budget.
3. The effectiveness period or service life of an alcohol program is the length of time during which the effects of treatment--A/R crash reductions--remain. For example the use of warning letters is estimated to continue reducing subsequent A/R accidents for six months to one year after the letter is received.

Some cautions are noted in the use of Table 3.1. The table contains a large number of question marks (indicating unknown information), and, in some places where data are given, there are wide ranges among the estimated effectiveness levels for a given countermeasure. As the reader will have noted repeatedly in the preceding discussions of countermeasures, the current state-of-the-art of evaluating these treatments has not precisely defined levels of effectiveness. Many gaps still exist. The information presented in Table 3.1 must be considered to represent the authors' estimates of countermeasure effectiveness based on a review of the best studies currently available. As such, the estimated ranges are not without error and are certainly subject to revision as subsequent evaluations are published.

Because these data are very necessary information to the economic analysis methodology to be presented in Chapter 4, the manual user is forced to use the following strategy. Where program costs or effectiveness levels or periods do not exist in the table or where wide ranges are given, the user must make his own estimates of levels which are appropriate for his own jurisdiction. Thus, for example, for a treatment involving short-term rehabilitation clinics for which no effectiveness levels are given in Table 3.1, the program manager might estimate that in his particular jurisdiction the program could be expected to reduce fatal A/R crashes by 20 percent, injury crashes by 10 percent and PDO crashes by 7 percent. Such estimates must be based on knowledge of both the A/R accident situation and the type of program possible in a given location. While such a use of estimates that are not based on well-conducted evaluations is far from optimal, it will allow the manual user to examine the potential cost-effectiveness of a given countermeasure program for a given group of individuals.

In summary, the information presented in Table 3.1 is not as soundly based nor as precise as would be desired. The user is urged 1) to remember that the information provided represented an attempt to define the best current estimates of effectiveness, 2) to stay abreast of new alcohol-related treatments and evaluations in order to continually update Table 3.1, 3) to use his knowledge of local conditions in his choice of appropriate effectiveness levels, and 4) to make use of the multiple analysis strategy discussed in Chapter 4.

Table 3.1. Summary of countermeasure information.

Countermeasure	Estimated A/R Crash Reductions: A/R Fatal Crashes	A/R Injury Crashes	A/R PDO Crashes	Treatment Costs	Estimated Effectiveness Period
1. Warning letters	4-20%	4-20%	4-20%	$ 0.50 - $ 1.50/letter	4 mo. - 8 mo.
2. Driver improvement clinics	0-?	0-?	0-?	$ 10.00 - $ 30.00/driver	?
3. Hearings	0-15%	0-15%	0-15%	$ 20.00 - $ 70.00/driver	7 mo. - 1 year
4. Probationary license for DUI first offenders	6-12%	6-12%	6-12%	Depends on information provided to judges	1 year
5. Short-term rehabilitation programs - Type 1-3 alcohol safety schools	?	?	?	$ 10.00 - $ 70.00/driver depending on school type	6 months?
6. Short-term rehabilitation programs - Power Motivation Training	?	?	?	$ 75.00 - $100.00/driver	?
7. Suspension/revocation of license	25-35%	25-35%	25-35%	Unknown, but relatively low	2 yrs. - 4 yrs.
8. Group therapy[ma]	?	?	?	$ 3.00 - $ 10.00/subject/session	?
9. Alcoholics Anonymous[a]	2-40%	2-40%	2-40%	?	?
10. Psychotherapy[a]	0-?	0-?	0-?	?	?
11. Aversion therapy[a]	10-40%	10-40%	10-40%	?	1-2 years
12. Direct chemotherapy[a]	2-50%	2-50%	2-50%	$150.00 - $200.00/driver/year	Throughout continued treatment

ma - most suitable for mid-range problem drinkers and alcoholics
a - suitable only for alcoholics within high-risk groups

Chapter 4

THE ECONOMIC ANALYSIS METHODOLOGY

Chapters 2 and 3 presented procedures for estimating the number of A/R crashes by severity and effectiveness levels, costs, and periods of effectiveness for countermeasures. This chapter presents the economic analysis methodology--the means by which program administrators can compare the cost of a chosen countermeasure program with the future benefits that can be expected from it. The information derived in the previous chapters is used to calculate estimates of this cost-effectiveness level--information that is critical to program administrators in the decision-making process. The costs involved will be actual dollar costs required for treatment implementation. Benefits will be stated in terms of the dollar saving resulting from reductions in A/R crashes.[1]

The use of any economic analysis method creates controversy among highway safety administrators for two reasons. First, an assumption must be made concerning the present value of future dollars (i.e., it is necessary to assign some interest rate that reflects the expected true value of money in the future). Second, since benefits are to be expressed in terms of dollars and the benefits are reductions in A/R crashes, a dollar value must be placed on human life and injuries, a practice that has drawn much heated discussion in recent years.

The first of these issues, the problem of estimating a suitable interest rate, or rate of return, has been explored by numerous economists. Two interest rates appear feasible. The lowest possible rate will be the current marginal borrowing rate of a public agency making an investment (between six and eight percent). The highest rate of interest for use as a discount rate in an economic analysis would be roughly equal to the marginal rate of return in long-term investments in the private sector which can be approximated by the going net rate of interest on private savings invested in real estate

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[1]*The reader should note that only accident-related benefits are to be used in the economic analysis methodology. While there are undoubtedly other societal benefits (e.g., reduction in adjudication and jail costs) and costs (e.g., cost of an individual's time spent in the treatment program), these will not be considered in the current analysis.*

(between 10 and 15 percent).[2] The most appropriate discount rate would lie somewhere between six percent and fifteen percent, depending upon the choice of economic philosophy. An average rate of ten percent will be used in the examples in this manual. The computer program presented in Appendix C allows the user to choose whatever interest rate he desires. It is suggested that the user consult local transportation economists or highway safety economists to determine their feelings about the most appropriate rate of interest.

The second problem, that of the necessity for specifying a dollar value for a human life and human injury, is more difficult to resolve. Studies that have attempted to determine the societal cost of highway-related fatalities, injuries, and property damage have produced a variety of estimates. Other authors have maintained that there is no possible way to place a value on human life and that any value is therefore artificial and erroneous. The dollar estimates for a fatality range from a high of $242,000 (1974 dollars--based on an NHTSA study) to a low of $90,000 (as estimated by the National Safety Council in 1972).

As was the case with the discount rates, the values for the various severity levels in the related forms and computer program may be changed by substituting whatever values the user feels are appropriate. However, for the remainder of the examples in this manual and for the computer program, the 1976 accident costs used will be as follows:

Fatal accident	$133,637
Injury accident	$ 10,946
Property-damage-only accident	$ 415

These estimates were developed from data in a 1974 North Carolina study by Barrett entitled, "Crashes and Costs: Societal Losses in North Carolina Motor Vehicles Accidents." In this study, Barrett uses $84,400 as the cost of a fatality in North Carolina, $5,350 as the cost of a non-fatal injury and $325 as the cost of a property damage only accident (1973 dollars). Because the methodology used in this manual is accident oriented, Barrett's figures were modified from an occupant base to an accident base. Using 1973

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[2]*For the reader interested in more extensive treatment of the economic basis for the various discount rates, a slightly broader discussion of this point was made in a report by Council and Hunter (1975) entitled "Implementation of Proven Technology in Making the Highway Environment Safe."*

North Carolina data, these changes were made based on the average number of fatalities per fatal accident, the average number of injuries per fatal accident, the average number of injuries per injury accident, and the average cost of a PDO accident. Using appropriate factors, and an expansion to 1976 dollars using changes in the Consumer Price Index (+27.8 percent between December 1973 and May 1976), the resulting 1976 figures are as shown above.

A final issue related to both this question of accident costs and to the problem of defining treatment effectiveness as discussed in Chapter 3, is the fact that the results of the economic analyses described below are very sensitive to the countermeasure effectiveness levels used. As will be noted in the following section, two important inputs to the economic analysis methodology are the level and period of effectiveness in terms of accident reduction for a given treatment. As was indicated in Table 3.1 and the related discussion, the current state-of-the-art of evaluation of these alcohol-related countermeasures has not precisely defined these levels. In many cases, only estimated ranges of effectiveness are given, and some of these ranges are quite broad for a given countermeasure (e.g., 0-15 percent for hearings). Because the choice of effectiveness level within this range directly affects the number of accidents reduced and thus the dollar value of benefits accrued (and because small differences in, say, fatalities reduced translate to large dollar differences), the user should exercise care in the choice of level used. This choice should be based on the users best estimate of treatment program effectiveness within his or her own jurisdiction; and on any future research findings related to treatment effectiveness. In addition, the user may wish to carry out multiple analyses for a given treatment employing different levels of effectiveness (e.g., a "pessimistic" level and an optimistic level) to determine the effects of these differences. The fact that the methodology has been computerized and that computer run costs are quite low facilitates such a strategy.

In summary, as noted earlier, the following economic analysis methodology is not without problems. However, sound user judgment concerning effectiveness levels coupled with the designed-in capability of multiple analyses can make this a very useful tool in the decision-making process. With future advances in knowledge, it can become even more exact.

The Economic Methodology to be Used-- The Net Discounted Present Value

After reviewing the various possible economic methodologies that might have been used in this analysis step, the net discounted present value (NDPV) was chosen.[3] The NDPV method gives the algebraic difference in the present worth of both outward cash flows and inward flows (benefits or incomes). For those users with economic backgrounds, the NDPV method is the same in principle as the present worth of costs method, but also includes the factor of annual income. It is a simple, flexible technique to identify the alternative having the greatest net present value as the one with the greatest economy.

Specific inputs required.

The NDPV methodology to be used requires the following specific information from the program administrator:

1. Number of A/R crashes which can potentially be affected. This first requirement is the predicted number of fatal, injury, and PDO accidents calculated by the user based on the models in Chapter 2. "Potentially affectable" refers to the fact that, if a given treatment were 100 percent effective, all the predicted accidents would be eliminated.

2. Number of drivers to be treated. The number of drivers in the homogeneous subgroup(s) to whom the treatment will be applied must be entered. In the example presented earlier, the predicted number of 40 accidents was calculated by applying the model to 1000 drivers. Thus the number of drivers to be entered would be 1000.

3. Effectiveness factor for the chosen countermeasure. The effectiveness factor is defined as:

   1 minus the percent accident reduction attributable to treatment

   Thus, for a treatment which will reduce A/R crashes by .10 percent, the effectiveness factor is:

   $$1 - .10 = .90$$

   This estimate of effectiveness is to be extracted from Table 3.1, Chapter 3; where a range of values or no value is given in the table, the user must make his own estimate or carry out multiple analyses.

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[3] *For the reader interested in a more detailed discussion of various methodologies, please refer to Council and Hunter (1975), "Implementation of Proven Technology in Making the Highway Environment Safe."*

4. Effectiveness period (service life) of the countermeasure. The length of time during which the treatment continues to reduce A/R crashes must be inputted. Again, information concerning this time period should be extracted from Table 3.1, Chapter 3, or estimated by the user. This input should be in terms of years (i.e., an effectiveness period of six months would be entered as 0.5 years).

5. Countermeasure costs. The total dollar costs of the chosen countermeasure must be entered into the program. These costs, both initial treatment costs and yearly upkeep or maintenance costs, may well vary from location to location, and in many cases will have to be estimated by the user. Baseline figures or ranges are presented in Table 3.1, Chapter 3. As noted in Chapter 3, part of these costs may be recovered from client charges. In these cases, the user must decide whether to include these as part of the societal cost of the program or whether to only include those costs which must be directly funded through a program budget.

6. Annual interest rate, or rate of return. As discussed earlier, the annual interest rate reflects the change in the estimated true value of money in the future. It should fall between 6 percent and 15 percent. This figure is used to determine the Present Worth Factor.

7. Inflation factor. The inflation factor designed to reflect the increasing costs of accidents and treatments with time must be estimated. For a 5.7 percent yearly rate, the inflation factor is entered as 1.057 in year 1. Subsequent yearly factors are calculated as follows:

   For year N, Inflation Factor =
   $[1 + \text{yearly inflation percent}/100]^N$

   Based on economic data, the following inflation factors are suggested:

Service Life	Estimated Average Inflation Rate	Inflation Factor
5	6.7%	1.067
10	5.7%	1.057
20	4.7%	1.047

   However, because there is disagreement among economists concerning the estimation and use of inflation factors, the user may wish to estimate a zero rate (enter 1.000).

Outputs of the economic methodology.

If the information described above is entered into the correct set of formulas, the result will be the net discounted present value of the improvement--the value in dollars of the treatment program in terms of today's money.

An example of the procedure followed may help to clarify this method. For a treatment program with an effectiveness period of ten years, the number of crashes reduced by the treatment is estimated by combining data concerning the number of potential A/R crashes (number of drivers in the high-risk subset x probability of an A/R crash for the subset) and data concerning the treatment effectiveness. The first year's program benefits are then calculated based on the dollar values of the crashes reduced. The first year's program maintenance cost is subtracted from this product.[4] The remaining difference between the first year's benefits and costs are converted (discounted) into this year's dollars using the appropriate present worth factor (PWF) for a given interest rate. This process is repeated for each year of the treatment's effectiveness period (service life), resulting in ten values, each of which is now expressed in terms of current dollars, or, to state it in economist's terms, each of which is at its present worth. (The reader should note that the present worth factor for Year 2 will be slightly different from the PWF for Year 1, reflecting the fact that future dollars will not be worth as much as present dollars.) Some of these differences may be negative values if a given year's costs are greater than the year's benefits. The final step in the process is to sum these differences, retaining the sign of each, and then to subtract the initial treatment costs. The remaining dollar value is known as the net discounted present value of the investment. If the sign is positive (+), the benefits of the program are greater than the costs; if the sign is negative, the costs are greater.

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[4]*It is noted that the term "first year," refers to the first year after treatment is completed. No benefits are assumed until treatment is completed. The treatment year is designated as year zero (0) for calculation purposes, and the initial treatment costs are already stated at their present worth. Yearly costs to be subtracted from yearly benefits include yearly maintenance or upkeep costs.*

This example, while somewhat simplified, reflects the general process to be followed. Actual computation procedures used are slightly more complex because they incorporate factors for changes in the yearly rate of inflation and procedures for eliminating fatally injured drivers from calculations for subsequent years. The computation procedures have been computerized and a complete listing of the PL1 program is included in Appendix C.

For the user not having access to a computer, four computation aids have been developed as guides to the step by step manual procedures. Blank copies of these forms which can be detached and photocopied for future use are provided in Appendix B. These aids include:

1. Form B-1: Calculation of treated and untreated A/R crashes. Calculation procedures for treated and untreated accidents are presented for each year of the treatment life. The inputs required are the number of drivers in the homogeneous subset being examined, the probability of an A/R crash from the appropriate Probability Table in Chapter 2, crash severity factors from Table 2.1, and treatment effectiveness factors calculated from data in Table 3.1.[5]

2. Form B-2: Predicted untreated and treated A/R crashes and crash reductions by severity. This form presents a summary of crash information calculated using Form A-1. The final three columns, the estimated number of fatal, injury, and PDO crashes reduced by the treatment for each year, represent the difference between the treated and untreated crashes.

   The calculated crash reduction in these final three columns can be totaled over the life of the treatment for use in calculation of such indicators as fatalities forestalled per program dollar, or A/R crashes forestalled per program dollar--outputs which may be used by the reader not wishing to conduct a more complete economic analysis.

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[5] *The user should note that the numbers of drivers and crashes used in the calculations on Form A-1 should have three or four decimal places (e.g., 2.0914 fatal crashes). The suggested use of these fractions will help eliminate potentially severe biases in the economic analysis which can result from rounding to whole numbers (i.e., the monetary difference between 1 and 2 fatal crashes is $140,586). The use of fractional parts of crashes is also justified by the purpose of the overall method--to predict the average reduction in A/R crashes resulting from application of a given treatment to a specific driver or group of drivers.*

3. Form B-3: Treatment process schematic. Because of the importance of correctly determining the defined timing of treatment implementation and maintenance in the economic analysis, form B-3 is a framework for a schematic of the project. The user should note the following points:

   a) The treatment period, regardless of total length, is always assumed to end at the end of year 0.

   b) The initial treatment cost is assumed to be incurred at the end of year 0.

   c) Treatment maintenance/upkeep costs are assumed to be incurred at the end of the project year(s) in which they are spent.

   d) The effectiveness period begins at the end of year 0 (i.e., the beginning of year 1) and ends at the end of a subsequent year.

4. Form B-4: Calculation of Net Discounted Present Value. On this final form, accident reduction data from B-2 and cost data from Form B-3 are combined in the final step of the economic analysis. Headings at the top of each column provide guides for the calculation steps necessary. The steps to be followed are:

   a) Transfer calculated accident reductions from form B-2 to column 1 of Form B-4, being careful to enter reductions accumulated in year 1 in the year 1 rows, year 2 reductions in the year 2 rows, etc.

   b) Multiply accident reductions (column 2) by the accident costs (column 3) to produce accident benefits, and enter these products in column 4.

   c) Within each year, sum the Fatal, Injury and PDO benefits to obtain total yearly benefits, and enter this in column 4 beside "Total = ."

   d) Enter total initial treatment cost in column 5 in the year 0 row.

   e) Enter the yearly upkeep or maintenance costs in column 6 in the appropriate year row. These data can be taken from Form B-3.

   f) Multiply maintenance costs (column 6) by inflation factor (column 7) and enter the inflated maintenance costs in column 8.

   g) Calculate the net cash flow for years 0, 1, 2, 3, . . . by subtracting appropriate costs from benefits within each year, and enter in column 9 (i.e., (9) = (4) - (5) - (6)). This will always result in the year 0 net cash flow being equal to treatment costs with a negative sign.

h) Calculate the present worth of each yearly net cash flow (column 11) by multiplying the NCF (column 9) by the present worth factor (column 10).

i) Finally, calculate the yearly cumulative balance (column 12) of the present worth net cash flow by adding the calculated present worth of the net cash flow to the prior year's cumulative balance. Thus for a given year, column 12 equals column 11 plus column 12 from the previous year, retaining all signs. The cumulative balance shown in the last block of the final year of the project life is the Net Discounted Present Value.

Example situation.

The example cited in Chapter 2 will be pursued at this point in order to clarify use of Forms B-1 through B-4 and to carefully examine the results of the NDPV methodology. This example assumes that 1000 young males with similar characteristics were identified using the appropriate model. It further assumes that these 1000 drivers were assigned to alcohol information classes (Driver Improvement Clinics) for five one-night sessions. From Table 3.1 and from personal knowledge of treatment programs and driving situations, the administrator has estimated that the effect of the clinic will last one-two years. The administrator has also decided to help extend this effectiveness period to three years by mailing a warning letter or a reinforcement letter to each of the 1000 drivers depending on each individual year's driving record at the end of the first and second year. The initial cost of the clinics is $30/driver and the warning/reinforcement letter, including driver record check procedures, will cost $1 per letter. The administrator has estimated that this treatment will reduce all A/R crashes involving these drivers by five percent for each crash severity.

Forms B-1 through B-4 have been completed for this example and follow on the next four pages. Although a step by step discussion of the procedure is not presented here, the user should be able to follow the calculation steps on the forms.

Form B-1. (Calculation of Treated and Untreated Crashes by Year)

YEAR 1

				1000 Number of drivers-year 1	x	.0396 Prob. of A/R crash	=	39.60 A/R crashes	x	.0397 F. Sev. Fac.	=	1.571 fatal crashes (untreated)	x	.95 F. Eff. Fact.	=	1.492 Fat. crashes (treated)
								39.60 A/R crashes	x	.4615 Inj. Sev. Fac.	=	18.275 Inj. crashes (untreated)	x	.95 Inj. Eff. Fact.	=	17.362 Inj. crashes (treated)
								39.60 A/R crashes	x	.4988 PDO Sev. Fac.	=	19.752 PDO crashes (untreated)	x	.95 PDO Eff. Fact.	=	18.765 PDO crashes (treated)

YEAR 2

1000 Number of year 1 drivers	-	1.571 Number of year 1 fatals	=	998.429 Number of drivers-year 2	x	.0396 Prob. of A/R crash	=	39.538 A/R crashes	x	.0397 F. Sev. Fac.	=	1.570 fatal crashes (untreated)	x	.95 F. Eff. Fact.	=	1.491 Fat. crashes (treated)
								39.538 A/R crashes	x	.4615 Inj. Sev. Fac.	=	18.247 Inj. crashes (untreated)	x	.95 Inj. Eff. Fact.	=	17.334 Inj. crashes (treated)
								39.538 A/R crashes	x	.4988 PDO Sev. Fac.	=	19.721 PDO crashes (untreated)	x	.95 PDO Eff. Fact.	=	18.735 PDO crashes (treated)

YEAR 3

998.429 Number of year 2 drivers	-	1.570 Number of year 2 fatals	=	996.859 Number of drivers-year 3	x	.0396 Prob. of A/R crash	=	39.476 A/R crashes	x	.0397 F. Sev. Fac.	=	1.567 fatal crashes (untreated)	x	.95 F. Eff. Fact.	=	1.489 Fat. crashes (treated)
								39.476 A/R crashes	x	.4615 Inj. Sev. Fac.	=	18.218 Inj. crashes (untreated)	x	.95 Inj. Eff. Fact.	=	17.307 Inj. crashes (treated)
								39.476 A/R crashes	x	.4988 PDO Sev. Fac.	=	19.690 PDO crashes (untreated)	x	.95 PDO Eff. Fact.	=	18.706 PDO crashes (treated)

YEAR 4

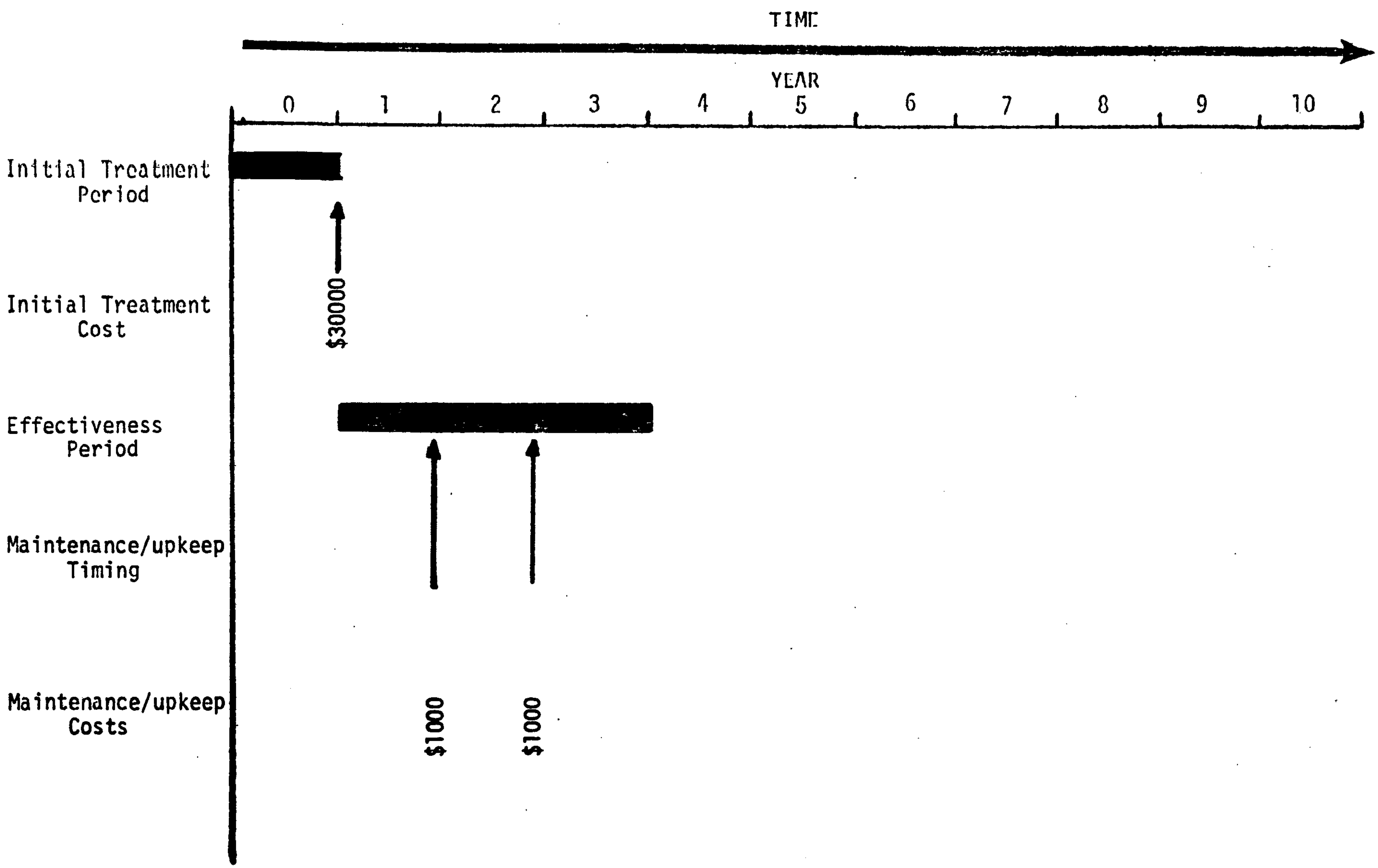
Number of year 3 drivers	-	Number of year 3 fatals	=	Number of drivers-year 4	x	Prob. of A/R crash	=	A/R crashes	x	F. Sev. Fac.	=	fatal crashes (untreated)	x	F. Eff. Fact.	=	Fat. crashes (treated)
								A/R crashes	x	Inj. Sev. Fac.	=	Inj. crashes (untreated)	x	Inj. Eff. Fact.	=	Inj. crashes (treated)
								A/R crashes	x	PDO Sev. Fac.	=	PDO crashes (untreated)	x	PDO Eff. Fact.	=	PDO crashes (treated)

Form B-2. Predicted untreated and treated A/R crashes and crash reductions by severity.

Predicted Crashes

	Untreated			Treated			Crash Reductions		
Year	F	Inj.	PDO	F	Inj.	PDO	F	Inj.	PDO
1	1.571	18.275	19.752	1.492	17.362	18.765	.079	.913	.987
2	1.570	18.247	19.721	1.491	17.334	18.735	.079	.913	.986
3	1.567	18.218	19.690	1.489	17.307	18.706	.078	.911	.984
4									
5									
6									
7									
8									
9									
10									
				Totals =			.236	2.737	2.957

Grand Total of Crashes Reduced = 5.930



Form B-3. Treatment Process Scheme

Form B-4. (Calculation of Net Discounted Present Value.)

(1) Year	(2) Accident Reductions	(3) Accident Costs ($)	(4) = (2)x(3) Benefits ($)	(5) Initial Treatment Costs ($)	(6) Maintenance Costs ($)	(7) Inflation Factor	(8) = (6)x(7) Inflated Maintenance Costs ($)	(9) = (4)-(5)-(6) Net Cash Flow ($)	(10) Present Worth Factor at 10%	(11) = (9)x(10) Present Worth of Net Cash Flow ($)	(12) Cumulative Balance ($)
0 (1976)	0	0	0	30000	0	1.000	0	-31000	1.000	-31000	-31000
1	F- .079 Inj.- .913 PDO- .987	$140,586 11,515 437 Total	11106 10513 431 = $22050		1000	1.052	1052	20998	0.9091	19089	-11911
2	F- .079 Inj.- .913 PDO- .986	$147,896 12,114 460 Total	11684 11060 453 = $23197		1000	1.107	1107	22090	0.8264	18255	6344
3	F- .078 Inj.- .911 PDO- .984	$155,587 12,744 484 Total	12136 11610 476 = $24222		0	1.164	0	24222	0.7513	18198	24542
4	F- Inj.- PDO-	$163,678 13,407 509 Total	= $			1.225			0.6830		
5	F- Inj.- PDO-	$172,189 14,104 535 Total	= $			1.288			0.6209		
6	F- Inj.- PDO-	$181,143 14,837 563 Total	= $			1.355			0.5645		
7	F- Inj.- PDO-	$190,562 15,609 592 Total	= $			1.426			0.5132		

Interpretation of results.

As indicated on Form B-4, the NDPV for the example analysis is \$25,662.57. This figure may now be interpreted for use in a decision-making process.

First, the sign of the NDPV tells the user whether the predicted program benefits outweigh the program costs. If the final NDPV is positive, the benefits are greater (as was the case in the example). If the final NDPV is negative, the costs are greater than the benefits and the program does not break even.

Second, the dollar value of the NDPV, if positive, indicates how much total return after costs the administrator can expect from his countermeasure (i.e., how much "profit" can be expected). In the example used, the societal benefits are \$25,662.57 (in 1976 dollars) after total costs are accounted for.

Finally, noting the year in which the cumulative balance changes from negative to positive, the user can predict when the countermeasure program achieves the break-even point, and, thus, how long the true effectiveness period must be in order for the project to break even, given the program costs and benefits specified. In the example, the benefits derived from the clinic/letter treatment program became greater than the program costs in year 2 (see Form B-4, column 12). Thus, in order to just break even, the program must reduce the A/R crashes by five percent for two years, rather than the three years estimated as its effectiveness period.

Comparison of Alternative Treatment Programs

This analysis may also be used by the user to aid in his choice of best treatment program from two or more alternative programs. Here, the user should repeat the entire procedure for each of the alternative programs. Then, using the calculated information concerning reductions in fatal, injury, and PDO crashes, total program costs, and the NDPV's for each alternative, the funding decision may be made. If the NDPV is to be the only decision criteria, and if all alternatives have equal effectiveness periods, the user should choose the alternative with the highest positive NDPV.

If all alternative treatments do not have equal effectiveness periods, an additional calculation is necessary before they can be compared. Each of the alternative investments needs to be converted into average annual cash flows (AACF). The resulting figure is the average benefit (or cost) which is incurred from the project during each year of the project's effectiveness period. To calculate this average annual cash flow, the calculated NDPV is multiplied by the capital recovery factor. This factor is equal to:

$$CRF = \frac{i(1 + i)^n}{(1 + i)^n - 1}$$

where i = discount or interest rate (10%)
n = effectiveness period for a given treatment

The average annual cash flows for the different alternatives are then compared, and the treatment with the highest AACF is chosen.

For example, assume that the program administrator had identified two possible treatments for the 1000 young male drivers. In addition to the clinic/letter treatment program discussed earlier, the administrator had decided to analyze a treatment involving group therapy sessions. The alternative, while more expensive and more effective, also has an effectiveness period of five years, in contrast to the three-year period for the clinics. Let us assume that the group therapy treatment, when analyzed, has a NDPV of $35,892.00 for its five-year life. Simple comparison of this NDPV with the NDPV for the clinic program would not be legitimate since it would ignore what might happen to the drivers under the clinic treatment in years 4 and 5. To overcome this problem, the average annual cash flows are calculated as follows:

1. For clinic/letter treatment

$$CRF = \frac{i(1 + i)^n}{(1 + i)^n - 1} = \frac{.10\ (1 + .10)^3}{(1 + .10)^3 - 1}$$

$$= \frac{(.10)\ (1.33)}{(1.33 - 1)} = .4021$$

Then:

$$AACF = NDPV \times CRF$$
$$= \$25,662.57 \times .4021 = \$10,318.42$$

2. <u>For group therapy treatment</u>

$$CRF = \frac{i(1 + i)^n}{(1 + i)^n - 1} = \frac{.10\ (1 + .10)^5}{(1 + .10)^5 - 1}$$

$$= \frac{(.10)\ (1.6105)}{(1.6105 - 1)} = .2638$$

Then:

$$AACF = NDPV \times CRF$$

$$= \$35{,}892.00 \times .2638 = \$9468.31$$

In this example, based on the economic analysis, the clinic/letter treatment would be chosen since, even though its NDPV is lower, it has a higher average annual cash flow. This same process can also be performed with more than two alternatives.

<u>The Computerized Economic Analysis</u>

The entire economic analysis procedure described above has been programmed for computer usage. The program, written in PL1, is reproduced in Appendix C for those users with access to computer facilities. Example printouts from the computer program for the clinic/letter treatment are shown on the following pages. For each program analyzed, the output will include an Accident Reduction Table (Table A) corresponding to Form B-2 and an Economic Analysis Table corresponding to Form B-4. The Accident Reduction Table contains a listing of A/R crash reductions by severity for each year of the effectiveness periods, the total numbers of fatal, injury, and PDO crashes reduced over the project life, and the grand total number of A/R crashes predicted to be eliminated. Again, these data can be used in calculation of fatal or total crashes reduced per program dollar invested.

The Economic Analysis Table printout contains inputted values for numbers of drivers, probability of an A/R crash, fatal severity factor, injury severity factor, PDO severity factor, fatal effectiveness factor, injury effectiveness factor, and PDO effectiveness factor. These values should be used as a check for input data errors. Below these inputs is the body of the table which corresponds to Form B-4 and includes the results of the year-by-year calculation. In every analysis, the Average Annual Cash Flow is automatically calculated for possible comparison with other treatment alternatives.

Summary

This chapter has presented an economic analysis methodology for use by alcohol program administrators. The methodology uses the information derived from the preceding chapters concerning predicted A/R crashes and possible countermeasures. The Net Discounted Present Value (and Average Annual Cash Flow) is then calculated for each proposed countermeasure program. If interpreted correctly, the results of this economic analysis are important tools which can be used by the administrator in the decision making processes.

ACCIDENT REDUCTION TABLE (A) : PREDICTED UNTREATED AND TREATED A/R CRASHES AND CRASH REDUCTIONS BY SEVERITY

STARTING YEAR : 1977

NUMBER OF DRIVERS : 1000

YEAR	CRASHES FOR UNTREATED DRIVERS			CRASHES FOR TREATED DRIVERS			CRASH REDUCTIONS		
	FATAL	INJURY	PDO	FATAL	INJURY	PDO	FATAL	INJURY	PDO
0	1.57	18.28	19.75	0.00	0.00	0.00	0.00	0.00	0.00
1	1.57	18.28	19.75	1.49	17.36	18.76	0.08	0.91	0.99
2	1.57	18.25	19.72	1.49	17.33	18.74	0.08	0.91	0.99
3	1.57	18.22	19.69	1.49	17.31	18.71	0.08	0.91	0.98
						TOTAL :	0.24	2.74	2.96

GRAND TOTAL OF CRASHES REDUCED = 5.93

Figure 4.1. Example computer output of Accident Reduction Table

ECONOMIC ANALYSIS TABLE (B)

STARTING YEAR 1977

NUMBER OF DRIVERS - - 1000
PROBABILITY OF A/R CRASH - - 0.0396
FATAL SEVERITY FACTOR - - 0.0397
INJURY SEVERITY FACTOR - - 0.4615
PDO SEVERITY FACTOR - - 0.4986
FATAL EFFECTIVENESS FACTOR - - 0.9500
INJURY EFFECTIVENESS FACTOR - - 0.9500
PDO EFFECTIVENESS FACTOR - - 0.9500

YEAR	TREATMENT COST ($)	MAINT COSTS ($)	A/R CRASH REDUCTIONS FAT	NFAT	PDO	ACCIDENT BENEFITS ($)	NET CASH FLOW ($)	PWORTH FACTOR @.10	PWORTH OF NET CASH FLOW $	CUMULATIVE BALANCE ($)
0	30000	0	0.00	0.00	0.00	0	-30000	1.0000	-30000	-30000
1	0	1052	0.08	0.91	0.99	23479	22427	0.9091	20388	-9612
2	0	1107	0.08	0.91	0.99	24661	23554	0.8264	19466	9854
3	0	0	0.08	0.91	0.96	25902	25902	0.7513	19461	29315

THE NDPV = $ 29315

THE AVERAGE ANNUAL CASH FLOW = $ 11708

Figure 4.2. Example computer output of Economic Analysis Table

Chapter 5

EVALUATION OF TRIAL PROGRAMS

Introduction

In Chapters 2-4, several tools have been presented which enable the alcohol program administrator to better identify high-risk drivers and to determine prior to implementation whether or not a possible countermeasure program is economically feasible -- essentially a "yes-no" decision. That is, even though a high-risk group of drivers has been identified, will the benefits of a given treatment be predicted to be great enough to justify the treatment costs? A positive answer to this question might result in countermeasure implementation; a negative answer might lead the administrator to further search for a different treatment or a different high-risk group. This economical analysis methodology is based on the inputs described earlier, including the effectiveness level of the treatment. As noted in Chapter 3 and 4, there are gaps in this necessary data. Effectiveness levels for many treatments are unknown, and there is a pressing need for alcohol program administrators to help fill these gaps by increasing both the quality and quantity of alcohol countermeasure evaluation. This final chapter presents a methodology for determining the effects of a trial alcohol countermeasure program which is implemented. It is included to meet the above noted need. As indicated, very little is presently known concerning the true effectiveness levels, effectiveness periods, or costs of the various alcohol countermeasure treatment programs that are available. Limited attempts are being made at the federal and state levels to fill these gaps in our knowledge. However, much more effort is needed in this area since the overall success of the entire alcohol program depends on a great extent on knowledge about the various treatments. Because alcohol programs operate at state and local levels, this need can only be met through increased participation in evaluation studies by state and local alcohol program administrators. The program administrator must be in charge of choosing a countermeasure, planning for proper evaluation of the countermeasure, conducting and interpreting the evaluation, and distributing the findings.

This chapter summarizes one methodology that can be used in the evaluation of alcohol countermeasures. It is not meant to be a detailed evaluation textbook nor is it meant to replace evaluation manuals that have been prepared and published in the past. Although this evaluation methodology is applicable to most highway safety program evaluations, it is oriented specifically toward the alcohol program area.

The material concerning evaluation methodology included in this chapter has been drawn from a number of past efforts. Primarily, the material is based on a series of state and national level workshops presented by the University of North Carolina Highway Safety Research Center for Governor's Highway Safety Representatives and other evaluation personnel, and on materials presented in The Evaluation of Highway Traffic Safety Programs: A Manual for Managers (Institute for Research and Public Safety, Indiana University, 1975). The manual user who is interested in exploring additional evaluation techniques is referred to this manual and to a recent NHTSA publication entitled, Management and Evaluation Handbook for Demonstration Projects in Traffic Safety DOT HS-802 196). Although the NHTSA manual also covers the planning and implementation procedure for demonstration projects, much emphasis is placed on program evaluation. In particular, Chapters XV, "Evaluation Designs," and Chapter XVI, "Selected Statistical Consideration and Techniques," contained an excellent overview of evaluation needs, problems, and procedures.

Type of Evaluation to be Conducted

The evaluation methodology presented in this chapter will be aimed at helping the manual user to carry out an effectiveness or impact evaluation (i.e., an evaluation aimed at determining how effective a specific countermeasure program is in reducing A/R crashes).

Other types of evaluation can be conducted for any given countermeasure activity, whether in alcohol or other safety areas. The two major types of evaluation have been classified as either process (administrative) evaluations or effectiveness evaluations. In a process evaluation, an attempt is made to determine how well a given countermeasure program was implemented. For example, in an alcohol countermeasure program involving the establishment and implementation of DUI educational programs, the measure of success in a process evaluation might well be the percentage of convicted DUI offenders ultimately attending the DUI schools. The process evaluation is, in effect, an accounting procedure. This type evaluation should be carried out for almost all safety-related activities, because a countermeasure program can only be effective if it is implemented properly. In some program areas, such as traffic records, process evaluation may well be the only practical evaluation.

However, because of the nature of the alcohol safety area and the nature of the countermeasure programs under study, the process evaluation is only the first step: effectiveness evaluation should be the goal. Not only should the implementation of the program be examined, but a measure of the benefits of the program in terms of A/R crash reductions should also be obtained.

Criterion to be Used

Direct measure - alcohol-related crashes

In any effectiveness evaluation of a safety countermeasure program, including those in the alcohol safety area, the criterion measure can best be defined by answering the question, "What is the countermeasure supposed to do?" With all the countermeasures discussed in this manual, the answer is, "The alcohol treatment program implemented is designed to reduce the frequency or rate of A/R crashes involving the treated drivers." This statement limits rather severely the crashes to be studied. The criterion to be used is not total accidents, nor even total A/R crashes in a given state or location. The only relevant crashes are those A/R crashes that the program has a reasonable expectation of affecting (i.e., those A/R crashes involving the drivers undergoing treatment).

What about proxy measures?

Because numerous past evaluations concerning alcohol countermeasure programs have used indirect or proxy criterion measures, some discussion of this practice is warranted. Proxy measures in the alcohol safety area are measurable variables that are substitutes for the frequency of A/R crashes. The most common proxy measure used in the past is a recidivism rate (i.e., a measure of the proportion of the drivers which are again picked up for DUI, readmitted to an alcoholic institution, etc., after treatment). A proxy measure is used when the criterion cannot be measured reliably (there are too few affectable A/R crashes) or when time constraints limit the follow-up period and thus the number of affectable crashes.

Although proxy measures can, at times, be valuable tools, their utility is limited by one important restraint: in order to be useful, the variable measured must have a known relationship to A/R crashes. Thus, recidivism rate is a good proxy measure if and only if a decrease in the recidivism rate has been shown by previous studies to be directly related to a decrease in A/R crashes.

An example of the proper use of a proxy measure is found in the speed enforcement area, where speed variance is often used as a proxy measure for the number of accidents in evaluating the effects of a speed enforcement program. Here, speed variance has been shown to have a direct relationship to total crashes. The lower the variance of speeds, the lower the probability of a crash.

Unfortunately, in the alcohol safety area, this link does not now exist. Even though the link between recidivism and A/R crashes appears to be quite logical, it has not been well documented. Because of this, a lowering of the DUI recidivism rates does not necessarily predict a reduction in A/R crashes. For this reason, the manual user is advised against using proxy measures, and encouraged to establish evaluation designs and implementation programs to directly measure the impact on A/R crashes for the group being treated.

The Evaluation Design

Numerous basic study designs can be employed in the evaluation of an alcohol countermeasure program. These designs range from the simple after-the-fact study to the more statistically sophisticated time-series analysis of longitudinal data. Each design has its strengths and weaknesses. A more detailed discussion of these can be found in the Indiana manual, in a study done by Griffin, *et al.*, entitled *Impediments to the Evaluation of Highway Programs* (1975), and in the NHTSA handbook.

This last handbook covers in detail the time-series evaluation design -- one of the strongest quasi-experimental analysis procedures now available. This design is particularly appropriate for alcohol countermeasure evaluations where the treatment must be applied to all possible subjects or locations (e.g., a statewide law requiring license suspension for DUI, or a legal requirement for alcohol schools for *all* first-time DUI offenders). However, as is discussed below, in cases where alcohol program administrators have some control over treatment procedures, there is a design which even better rules out alternative explanations for an observed effect and can often make better use of the most appropriate criterion, the alcohol-related crash.

Recommended design-modified before/after with control.

The one design, which, when properly conducted, may well be the strongest design possible in the evaluation of highway safety programs is referred to as a *before/after study with control group*.

The standard before/after with control design requires the delineation of two equal groups well before the treatment program is implemented. This forces the program administrator/evaluator to map out an evaluation procedure as the treatment implementation is formulated. The criterion measure (e.g., crash rates) is then measured for each group prior to implementation. The treatment group is then administered the countermeasure program, while the control sample is not treated. The two groups are then followed in time over the life of the countermeasure activity. Finally, their A/R crash rates are compared in order to determine how much of the change in the crash rate is due to the treatment program.

The design that is used in the following alcohol-related example is a slightly modified version of the before/after with control design in which data prior to implementation are not collected. The deletion is made possible by the fact that in most alcohol countermeasure programs, relatively large samples of drivers can sometimes be identified, and these potential treatment subjects can be separated into two equal groups. If a large sample of similar drivers is randomly assigned to two groups, the crash rates for both groups should be approximately equal because the random assignment procedure should equalize the effect that extraneous factors (e.g., exposure rates) might have on the two groups.

The possibility of using a random assignment procedure is not always present in safety program evaluations, and it has been used very seldom in the past, even where possible. However, the alcohol program administrator/-evaluator can and should use this tool because it results in both a stronger evaluation and, as will be noted later, a more powerful statistical test.

The modified design requires the delineation of a non-treated control group, a requirement objected to by program administrators. Their understandable desire is to treat all individuals equally and compare their accident rates following treatment with their rates prior to treatment (i.e., a simple before/after design). Unfortunately, the results of the simple before/after study are often fallacious because the underlying assumptions which must be made in using the design are not met. The main assumption is that all other causative factors are equal in the two time periods, that therefore, any change in the A/R crash rates from the before period to the after period is a direct result of the program. In many cases, however, these changes would have occurred without implementation of the treatment program because of changes in other related variables. That is, other causative factors, such as a change in the economic situation, a fuel crisis, a change in the drinking/driving laws, or a change in the availability of alcohol, may well result in a change in the A/R crashes between the before and after periods and bias the data.

Further compounding the problem is a regression to the mean phenomenon. Regression to the mean occurs when two variables that are not perfectly related to each other (such as A/R crash rates in two time periods) are studied. Here, if the first point in time was either extremely high or low, the second point will be closer to (or regress toward) the mean value by chance. As a specific example, if a group of "high-risk" drivers are identified because of their high A/R crash rate during a one-year period of time, then, because of the regression to the mean phenomenon, the crash rate of this group during the next one-year period will be lower. Thus, if a treatment program was introduced between year 1 and year 2, the subsequent lowering of the A/R crash rate could possibly be due either to the treatment program or (either totally or in part) to regression to the mean. Even if the treatment program were effective, the true level of effectiveness could not be isolated from the reduction due to regression to the mean.

Because of these weaknesses in a simple before/after study design, administrators are encouraged to use a before/after study with a control group. The use of a control group can greatly reduce such problems. First, any decrease in A/R crashes that is due to some extraneous factor should occur in both the treatment and the control groups. In addition, any reduction resulting from regression to the mean would also occur in both groups. Thus, any <u>difference</u> in the reductions at the end of the after period can be attributed to the program. The comparison is not between the before crash rate and after crash rate, but is, instead, between any differences in the change in crash rates from before to after for the treatment and control groups.

For example, assume that, in the before period, experimental and control groups of equal numbers of drivers had each experienced 100 A/R accidents. Treatment was then instituted in the experimental group, which, in the after period accumulated 50 accidents; the control troup accumulated 60 accidents. In a simple before/after study where only the experimental group is examined, it would be concluded that the treatment caused a reduction from 100 to 50 crashes: a 50 percent reduction would be attributed to the program. Given the more appropriate before/after with control design, the true reduction due to the treatment program would be calculated by subtracting the number of crashes experienced by the treatment group -- 50 -- from the number of crashes experienced by the control group -- 60 -- and dividing the difference by the predicted number. Thus, the true percent reduction due to the treatment would be estimated to be (60-50) ÷ 60, or 17 percent.

The benefit of the before/after with control design is shown even more dramatically by a second example. Assume that the same before period rates occurred for the experimental and control groups as in the above example (i.e., 100 A/R crashes for each of the groups). In the after period, now assume that the experimental or treatment group again accumulates 100 accidents while the control group accumulates 120 crashes. With a simple before/after design where the program effectiveness is based only on the experimental group, the evaluator would conclude that the program had no effect. However, using the before/after with control design, the data indicate that the control group's A/R crashes increased by 20 percent. This same increase would be predicted for the experimental group if no treatment had been applied. Thus, rather than showing no effect, the treatment program reduced A/R crashes by 20 (the difference between the observed 100 crashes and the predicted 120 crashes). The percentage reduction in A/R crashes due to the treatment is estimated to be (120-100) ÷ 120 = 17 percent.

The alcohol program administrator is in a rather select group of safety administrator/evaluators who can employ this strong before/after with control design. The nature of other safety-related programs where the countermeasure must be applied to the entire jurisdiction or group makes the use of this design very difficult, if not impossible. For example, the recent fuel crisis and subsequent lowering of the speed limit to 55 mph and the concurrent reduction in crashes and fatalities drew a great deal of research effort in an attempt to isolate the true effect of the lowered speed limit. However, no control sample could be established because the law was implemented nationwide. Because of legal constraints, no sections of interstates, for example, were left with a higher speed limit to serve as control sites. For this reason, isolation of the effect of the lowered limit from other causative factors (e.g., less fuel, changes in driving patterns, changes in traffic volumes) was almost impossible.

Alcohol program administrators are, in many cases, not restrained in similar ways. The nature of many alcohol countermeasures is that they are actual treatment programs aimed at a relatively small group of drivers who have been preselected. Because of this fact, establishment of control groups is often possible with proper planning. Administrators should make every effort to use this very strong study design in order to produce usable, clear-cut, and scientifically sound information.

Objections are sometimes raised to the use of control groups because this practice appears to discriminate against the persons who are withheld from treatment they are known to need. However, with proper planning before program implementation, the administrator can use both political and fiscal restraints placed on him to establish a control group and still not leave himself open to charges of discrimination. Two arguments can be made. First, there is never enough money in any alcohol countermeasure program to treat all the drivers who need treatment -- larger groups of needy drivers can always be identified. Second, because funding is not sufficient to treat all drivers, some decision must be made concerning which drivers receive treatment. The method advocated here for determining who receives treatment is a random process, such as flipping a coin. There is no fairer or more nondiscriminating process for assigning drivers to treatment and control groups: every driver that is in the affectable group has an equal chance of receiving treatment and no other process of defining experimental and control groups is as valid statistically. Thus, by philosophically basing a random assignment technique on the realities of fiscal limitations and on the political need to fairly decide who is to receive treatment, the administrator/evaluator is able to establish, at no additional cost, a control group which can help to accurately determine countermeasure effectiveness.

Finally, also of importance in one's planning of an evaluation is the determination of the appropriate sample size -- i.e., how many treatment and control subjects need to be chosen. Since this chapter can only serve as an overview to evaluation procedures, a detailed discussion of sample size selection will not be presented. The user should note that the "correct" sample size is related to the anticipated degree of effectiveness, the average A/R crash experience of the subjects, the length of the study's duration, and the statistical test and statistical significance level to be used in the data analysis. If too small a sample is used, even if the treatment results in a meaningful reduction in A/R crashes, the difference may not prove to be statistically significant, and thus, must be viewed with some reservations. (A more detailed discussion of statistical testing is presented later in this chapter.) In short, the administrator who is planning an evaluation should discuss with a statistician the size that the sample should be. Additional discussion can be found in the earlier referenced evalution manuals and in many statistical texts.

Example Situation

The above information will now be integrated into the process that has been developed thus far in the manual using an example similar to that presented throughout Chapters 2-4. Assume that the administrator has decided to implement and evaluate a treatment program involving a DUI clinic for young male drivers. In order to conduct a sound evaluation, the administrator must carry out evalution planning well before implementing the program. The administrator has $30,000 to spend on an alcohol countermeasure program (the same amount used previously in the economic analysis), and knows that this $30,000 will treat approximately 1000 drivers who are placed in a DUI clinic program. Thus the administrator is limited to treating a high-risk group of approximately 1000 drivers. He or she has talked with a statistician concerning sample size and has been told that, with an estimated effectiveness level of 10 percent, and with 1000 drivers in the treatment group, he will need an additional 1000 drivers in a control group. Using the predictive models, the administrator has identified 3000 young males with the characteristics used in Chapter 2 and who, therefore, have the same expected probability of an A/R crash in a one-year period of time.

The administrator (now turned evaluator) should first take the 3000 drivers and randomly assign them into two groups, one containing the 1000 drivers he has funds to treat and one containing the remaining 2000 drivers who will serve as a control group. (Although 1000 drivers would have been adequate, the increased size of the control group will cause any real differences between the after-treatment accident experience of the two groups to be even more easily detected while costing very little to study.) This randomization process may be done in a number of ways. The simplest way is to place three slips of paper in a box, one slip having the letter "t" (treatment) written on it and two slips having the letter "c" (control) written on them. With a list of the 3000 drivers in hand, he begins randomly assigning individuals by drawing one of the three slips, looking at it, and replacing it into the box. If the slip drawn has a "t", the driver is placed in the treatment group; if the slip drawn has a "c", the driver is placed in the control group. The drawing is repeated for each of the 3000 drivers. At the end of the process, the sample of 3000 young males will be divided into two groups with approximately 1000 drivers in the treatment group and 2000 in the control group.

The drivers in the treatment group are then exposed to the countermeasure treatment while the drivers in the control group are untreated. Following the treatment program (year 0) the driving experience of both groups is monitored for three years.

At the end of the three-year period, the number of A/R crashes involving the control group and the number involving the treatment are compared. Hypothetical results of this data collection process are shown in Table 5.1.

Table 5.1. Alcohol-related crash data for the three-year period following treatment.

	Number of Drivers	A/R Crashes After Treatment
Treated Drivers	1000	103
Control Drivers	2000	240

As indicated above, the treatment group of 1000 drivers experienced 103 A/R accidents in the after period. The control group, with twice as many drivers, experience 240 A/R accidents in the after period.

First, calculate the number of crashes in which the treatment group would have been involved if no treatment had been administered. This prediction is derived on the experience of the control group. In the table above, the control group experienced 240 ÷ 2000 or 0.12 A/R crashes per driver. If no treatment had been applied, the same A/R crash rate would be predicted to occur within the treatment group since the random assignment procedure is assumed to cause all extraneous factors to have an equal effect on both groups. Thus, based on the experience of the similar control group, the treatment group would be predicted to have 0.12 crashes per driver, for a total of 120 (.12 x 1000 = 120).

Using this expected number of crashes, the percentage reduction attributed to the treatment program can be calculated. The predicted value for the treatment group is compared to the actual or observed value (i.e., 120 predicted crashes is compared to 103 observed A/R crashes). The difference between these two numbers, divided by the predicted value, represents the percentage reduction due to the program. Thus,

$$\text{Percent Reduction} = \frac{(120 - 103)}{120} = 14.17\%$$

This figure is much higher than the five percent reduction estimated in the earlier economic analysis.

Statistical test.

To many alcohol program administrators, the most confusing aspects of any research report is the information dealing with statistical significance testing and the interpretation of these results. There are a large variety of statistical tests which are used, an infinite number of statistical tables that must be referred to, and numerous ways of interpreting results. Because many of these tests are appropriate for use with alcohol countermeasure program evaluations, a full discussion of all of them is impossible. In addition, the material presented here is not designed to be a detailed explanation of the total evaluation process. However, the confusion and annoyance associated with the multitude of statistical procedures used by researchers can be alleviated to some degree by some knowledge concerning the purpose of statistical tests and the underlying laws governing their use. For this reason, some general information is presented in the following section. The program administrator with a sound background in statistics may skip this material, but the program administrator without such a background or the administrator in need of a basic review should examine this section. While the administrator does not have to be a statistician, he should have the tools and knowledge that can, at a minimum, make his interpretation of results easier. It is, after all, the program administrator and not the statistician who must evaluate a research finding and make the final decision concerning whether the finding does or does not warrant the expenditure of his limited funds to either implement a new program or revise an old one.

Statistical test--a tool for determining when a difference means something.

Despite the number of statistical tests available for use in most analysis problems, the alcohol administrator should realize that all these tests have only one purpose--to help the evaluator determine whether or not an apparent difference really means something in terms of program effectiveness. In the above example, the calculations indicated that the treatment program resulted in a 14.17 percent decrease in A/R crashes. The appropriate statistical test is designed to answer the question, "Can this 14 percent difference be attributed to the program or does it simply reflect chance variation in the number of A/R crashes from year to year?"

The statistical test, logic and procedure.

Thus, the overall goal of the testing procedure is to determine, with a given set of odds, whether or not a particular difference should be attributed to the treatment or to chance alone. If statistical test procedures followed the logical chain found in most other decision-making processes involving odds or probabilities, the evaluator would calculate the odds that the treatment caused the difference, and if the odds were high enough he would conclude that the difference was due to the treatment.

Unfortunately, this is not the procedure followed in statistical testing. Indeed, at first glance, the logic that is used appears to be backwards. Instead of the above noted normal logic, the use of any statistical test requires the following steps:

1. With a given numerical difference (e.g., between the before and after period data or between the observed and predicted values for the treatment group), the statistician calculates the odds that chance alone could cause such a difference.

2. If the odds that chance alone could cause the difference are low enough, the statistician infers that the treatment caused the difference.

Thus, rather than calculate the odds that the treatment caused such a large difference, the statistical test allows the evaluator to calculate the probability that chance could have caused a difference of this size. If the odds are low enough, the evaluator concludes that because chance did not cause the difference the treatment did; therefore, the difference is "statistically significant."

The odds that chance caused the difference are usually expressed as an alpha level or as a p-level or probability value. (In laboratory studies for statistical significance, these alpha or p-levels usually range between .05 and .001. However, for evaluations involving social impact studies of real-world events, the acceptable levels may be as high as .20.) For example, if a given study indicates that a difference is significant with an alpha of .05, the statistician is telling the reader that the probability that a difference this size would result from chance alone is .05, or five chances out of a hundred. Conversely, this means that 95 times out of 100, chance alone would not have caused a difference this large. Because the odds of chance alone causing the differences are so small, the statistician then infers that the treatment caused the difference and notes that a statistically significant difference exists at the .05 level.

The information presented in the paragraphs above may seem quite complex to the administrator who does not have a statistical background. Indeed, this information represents the basic framework of material which would normally require two to four months of a basic statistics course. However, the important thing for the administrator to remember in any statistical testing is that the researcher is simply calculating the odds that a given difference resulted from chance variation; if these odds are low enough, the researcher infers that the difference is due to the treatment that has been implemented.

Choice of Proper Statistical Tests

The choice of which statistical tests to use in a particular study is based on two things: (1) the type of data being examined, and (2) the type of experimental design used in the data collection process. In evaluating any safety program, an administrator should consult a trained statistician for help in this choice.

In reading outside evaluation studies the administrator must assume that the correct test was used. While review of current studies indicates that in some cases an evaluator uses improper tests, the error is so rare that the administrator can be fairly confident that appropriate tests were used.

The final section presents a general statistical testing procedure that is appropriate for use with most A/R treatment programs. The procedure will be used in completing the analysis of the example data.

Recommended Statistical Test and Example Procedure

The alcohol program administrator who is familiar with evaluation studies in the field will probably be most familiar with one particular statistical test--the Chi-square. This test is appropriate for most alcohol-related treatment evaluations because of its very general assumptions concerning the underlying data. It is particularly useful with two-sample designs (i.e., treatment and control samples) where count data (e.g., the number of A/R crashes) are used. Thus, it would be appropriate for use with the example data.

However, even though correct, the statistical test procedure recommended here is not the Chi-square procedure, but instead, is a test of the difference in the proportion of drivers experiencing A/R crashes in each of the two groups. The specific procedure is felt to be more powerful than the Chi-square test for the specific evaluation design and A/R data characteristics proposed for two reasons:

1. The number of A/R crashes will always be relatively small even though samples of drivers may be large, because A/R crashes are a very low probability event.
2. The percent reduction due to most A/R countermeasure programs, and therefore, the observed difference between the predicted and observed values, will be relatively small. Very few, if any, countermeasure programs should be expected to reduce A/R crashes by more than 35 to 40 percent.

The alcohol program evaluator's data consist of relatively small numbers of crashes and small reductions in these numbers resulting from a treatment program. In order to detect a statistically significant change, the statistical test used must be very sensitive and should use all available data, including the number of drivers in each sample.

Based on these considerations, the recommended test procedure involves the proportions of A/R crash-involved drivers in both the control and treatment group. Under the assumption that these proportions are binomially distributed, the following test statistic may be used:

$$z = \frac{p_c - p_t}{\sqrt{\frac{p_c(1-p_c)}{n_c} + \frac{p_t(1-p_t)}{n_t}}}$$

where

p_c = proportion of control group involved in A/R crashes

p_t = proportion of treatment group involved in A/R crashes

n_c = number of drivers in the control group

n_t = number of drivers in the treatment group

This test statistic, z, is approximately normally distributed and may be compared with the standard normal distribution in order to determine the probability that the difference observed is due to chance. Statistically, this will always be a one-sided test since the user only wishes to know whether the treatment group is significantly better than the control group in terms of crash rate.

As indicated above, the z which is calculated can be compared to the standard normal distribution found in all statistics books to determine the probability that a difference as large as the one observed could be due to chance. For convenience, the following values have been taken from John E. Freund's Modern Elementary Biostatistics (Prentice-Hall, Englewood Cliffs, N.J., 1967 [3rd. ed.]).

z	Probability of Difference Due to Chance
2.327	.01
1.645	.05
1.282	.10
0.852	.20

Thus, if the calculated z is, for example, 1.345, the probability that the difference is due to chance is between .10 and .05 (odds between 1 in 10 and 1 in 20) and the evaluator would conclude that the treatment resulted in a statistically significant difference at the $\alpha < .10$ level.

In our example, the required input data are:

$$p_c = .120$$

$$p_t = .103$$

$$n_c = 2000$$

$$n_t = 1000$$

Using the above formula,

$$z = \frac{p_c - p_t}{\sqrt{\dfrac{p_c(1-p_c)}{n_c} + \dfrac{p_t(1-p_t)}{n_t}}}$$

$$= \frac{.120 - .103}{\sqrt{\dfrac{.120(1-.120)}{2000} + \dfrac{.103(1-.103)}{1000}}}$$

$$= 1.411$$

In this example, the evaluator concludes that the possibility that the observed difference is due to chance variation is less than .10. Based on this, he would infer that the 14 percent decrease in A/R crashes was a real difference due to the treatment (i.e., that the difference was statistically significant at the $p < .10$ level).

The reader with a statistical background will have noted the inclusion of probability levels of .10 and .20 in the preceding table and discussion. In most traditional statistical courses, α or p-levels of greater than .05 are not recommended. However, many statisticians involved in evaluation of social programs have argued for liberalizing the significance levels on the basis that, like an evaluation of A/R countermeasures, many of these evaluations are concerned with studying human behavior, not in a laboratory, but in a real world setting where known and unknown extraneous factors exist. It must also be noted that use of a more stringent α level increases the odds of not detecting a real program difference (i.e., the Type II or β error). For these reasons, the use of a more liberal significance level (e.g., α = .10 - .20) may well be justified.

Distribution of Results

In many evaluations, the procedure ends once the effectiveness of the program has been calculated. What may well be the most important point of this entire evaluation procedure does not take place -- the distribution of results to other alcohol countermeasure program managers and related professionals in the field.

As indicated earlier, the only solution to the problems cited in Chapter 3 is a tremendous increase in the number of sound evaluations of alcohol countermeasure programs. However, an increase in this number of evaluations without the distribution of their results would be meaningless. The program managers who evaluate a treatment program must also be responsible for distributing this newly gained knowledge to fellow professionals. The administrator must become part of some network of information distribution. Many facilitating organizations and structures now exist for this purpose. These include the National Highway Traffic Safety Administration, public information sources including various newsletters and workshops, the Transportation Research Board publications and annual meeting, periodic meetings of ASAP program directors on a regional as well as national basis, various highway safety journals such as the Journal for Safety Research, and, finally, distribution of the results in a brief technical report mailed to all other Governor's Representatives or ASAP managers across the nation. Whatever the structure used, the dissemination must be made in order that the knowledge not die on the shelf.

Summary

This chapter has provided the alcohol program administrator with a methodology for evaluating trial alcohol programs -- the final of a set of tools designed to aid him in his decision-making process. While the material presented has not been extensive, the basic concepts of sound evaluation have been presented. While the major goal of this manual and the companion research project was the development and presentation of a tool to better identify alcohol-related problem drivers, in the final analysis, the procedures discussed in this chapter may well be more important than the models, if these procedures are followed. Without factual information concerning the true effectiveness of the various alcohol countermeasures, the alcohol program administrator must make crucial program decisions based on, at best, that individual's estimation of program worth. The only way the gaps in our mileage concerning these countermeasures will be filled is through greatly increased implementation of well planned, scientifically sound evaluations.

APPENDIX A

Statistical Development of the Predictor Models

Material in this appendix is taken from Techniques for Predicting High Risk Drivers for Alcohol Countermeasures. Volume I: Technical Report. The reader wishing a more detailed description is referred to that volume.

MODEL DEVELOPMENT

The objective of the statistical analysis was the development of a predictor model for A/R crashes using as independent variables those data elements which are most strongly associated with A/R crashes. Automated statistical procedures, such as stepwise multiple regression and stepwise discriminate analysis, can both select variables in an "optimal" manner and include them in a predictive model. These procedures, however, were developed for situations where one or all the variables could be assumed to be continuous and normally distributed, while in this project the dependent variable (number of A/R crashes) and all of the potential independent variables are of a categorical nature (driver age can be treated as a continuous variable, but, since its relationship with traffic crashes is highly non-linear, it is also best treated in terms of age categories). It would be possible to use a method such as stepwise regression analysis with the dependent variable taken as either the number of A/R crashes or as a zero-one variable indicating the absence or presence of A/R crashes, and with the independent variables being dummy variables indicating all the levels of the categorical variables and their complex interactions. The statistical tests resulting from such analyses, however, could only be considered to be valid in an approximate sense.

On the other hand, in recent years, analogous statistical methods have been developed specifically to deal with the categorical variable case (Grizzle, et al., 1969). These methods make use of the categorical nature of the data, and therefore, are more efficient than the methods designed for continuous variables when, in fact, the variables are categorical. At present, however, no satisfactory automated procedure is available for simultaneously selecting variables and model building with respect to categorical variables.

Thus, the development of multivariate models for the prediction of probabilities of alcohol related crash involvement entailed two essentially separate phases. The first phase involved selecting a subset of those variables which were descriptive of events prior to 1975 and were most strongly related to 1975 crashes from among the many possible variables available on the data file for each high risk group. The second phase consisted of fitting categorical regression models to the populations defined by the variables selected in phase one.

Table A-1 shows a list of the variables available on the data files for possible inclusion as predictor variable for A/R crashes. As noted in the footnote, the values of each of the driver history variables were accumulated over as many as eight six-month intervals. Thus, it was necessary to select the most appropriate time frame for those variables for each high risk group. It was also necessary to select the levels on value ranges for nearly all the variables to be used in the modelling procedure.

To accomplish this task, for each high-risk group a series of two-way contingency tables of A/R crash involvement versus the variables listed in Table A-1 were examined to identify which variables with which levels of value ranges and time intervals had the strongest relationship with A/R crashes while maximizing cell size and percentage of A/R crashes. The first step was, therefore, to identify for each group, the variable showing the strongest relationship with A/R crashes. The strength of the relationship was assessed by examining the χ^2 statistic or χ^2/degrees of freedom from the contingency table analyses.

The next step in the variable selection process was to select another variable for each group which contributed the most toward the prediction of A/R crashes beyond that contributed by the first variable. To do this, three-way contingency tables were analyzed of each of the remaining variables versus A/R crashes and the variables selected in the first step. The variable which together with the initial variable selected accounts for the largest variation in the A/R crash rate is tested for significance using the procedure described by Clarke and Koch (1974). If it is significant, it is retained; if not, then the one with the next largest variation is tested, and so on. If no variable is significant, then none is selected. Additional variables are selected using nearly the same procedure. Often by this stage some cell sizes become so small that they might render the χ^2 statistics invalid. Also, it is often important that the relationship between the variable being considered and A/R crashes be consistent across the various subtables. A statistic which is valid for subtables with small

Table A-1. Variables examined in variable selection process.

I. Demographic variables

1. Age
2. Sex
3. Race
4. Divorce
5. Prison

II. Accident variables

6. Total crashes
7. Total A/R crashes
8. Total night crashes
9. Time of week
10. Locality
11. Weather
12. Severity
13. Accident type
14. Occupants
15. Type of violation

III. Driver history variables

16. No. of speeding convictions (or violations)
17. No. of stop convictions (or violations)
18. No. of moving convictions (or violations)
19. No. of reckless convictions (or violations)
20. No. of alcohol convictions (or violations)
21. No. of administrative convictions (or violations)
22. No. of accidents at fault
23. No. of suspension & revocation violations
24. No. of equipment violations
25. Total violations
26. Total accidents
27. Total 4-point letters
28. Total 7-point letters
29. Total suspensions
30. Total revocations
31. Total conferences
32. Total hearings
33. Total preliminary hearings
34. Total accidents not at fault
35. Total days of suspension and/or revocation

IV. Alcohol related arrest variables

36. No. of violations
37. No. of day violations
38. No. of night violations
39. Blood alcohol concentration
40. No. of crash involved arrests
41. No. of DUI's tried
42. No. of other offenses tried
43. No. of DUI convictions
44. No. of other convictions
45. No. of not guiltys for noted offense
46. No. of PJC's
47. No. of nol pros's

*The values of the driver history variables are accumulated over six month intervals for eight such intervals; thus there is a choice of the best time frame for each group.

cell sizes and which emphasizes consistency is the modified Mantel-Haenszel statistic. It was used as the test statistic after the second or third step depending on group size. A general discussion of Mantel-Haenszel procedures can be found in Fleiss (1973) and its use in variable selection is discussed in Clarke and Koch (1974). The variable selection procedure was terminated either when no more significant variables remained or when the data had been partitioned to the extent the high risk subgroups contained so few individuals that further subdivision was not feasible. The variables selected for modeling for each of the high risk groups are shown in Table A-2.

After predictor variables were determined for each of the high-risk groups, categorical data models could be developed to predict A/R crash rates in terms of these variables. The final crosstabulations from the variable selection phase provides the definitions of a set of categories or subpopulations together with frequencies and proportions of the occurrence of A/R crashes for each subpopulation. For example, four variables were selected for the general population group each having two levels. The combinations of these levels generate sixteen distinct subpopulations. Table V shows these subpopulations together with their respective A/R crash frequencies, proportions, and the standard errors of the proportions. Thus, the first subpopulation corresponds to males with no days suspension/revocation, no accident violations, and no reckless violations. The proportion of the 77,701 drivers in this subpopulation who had A/R crashes in 1975 was .00281.

Linear categorical models were then fit to the resulting column of observed proportions for each set of variables (more than one set of variables having been chosen for some high risk groups). These models are of the general form

$$P = XB$$

where P is the vector of subpopulation A/R crash proportions, X is a design matrix whose columns represent effects due to the variables and their interactions, and B is a vector of model coefficients to be estimated. A discussion of these models can be found in Grizzle, Starmer, and Koch (1969).

The observed proportion for a given subpopulation is determined from the A/R crash frequencies for that subpopulation only as are the estimated standard deviations or standard errors. The model provides estimated or

Table A-2. Variables selected for A/R crash prediction models.

Group	Variable	Levels
Males, 16-20	1. Total days suspended/revoked (S/R) (1 yr.)	none, one or more
	2. Total violations (1 yr.)	none, one or more
	3. Night crashes (73-74)	none, one or more
	4. Night violation arrests (1 yr.)	none, one or more
Males, 21-24	1. Total days S/R (4 yrs.)	none, one or more
	2. Reckless violations (4 yrs.)	none, one or more
	3. Alcohol violations (4 yrs.)	none, one or more
	4. AR crashes (73-74)	none, one or more
DUI	1. Driver age	20 or under, 21-25, over 25
	2. Speeding violations (1 yr.)	none, one or more
	3. Total days S/R (3 yrs.)	less than 185, 185 or more
	4. Reckless violations (1 yr.)	none, one or more
3+ Violations	1. Age	under 21, 21 and over
	2. Total days S/R (3 yrs.)	none, one or more
	3. AR crashes (73, 74)	none, one or more
	4. Night crashes (73, 74)	none, one or more
	5. Sex	M, F
Divorce	1. Alcohol violations (4 yrs.)	none, one or more
	2. Reckless violations (3 yrs.)	none, one or more
Prison	1. Reckless violations (4 yrs.)	none, one or more
	2. Age of driver	thirty or under, over 30
General Population	1. Total days S/R (4 yrs.)	none, one or more
	2. Accident violations (4 yrs.)	none, one or more
	3. Sex	M, F
	4. Reckless violations (4 yrs.)	none, one or more

predicted proportions, however, that are determined from the frequencies from all of the subpopulations. Thus, in effect, the model "smooths" the raw proportions to yield the predicted ones. The standard errors of the predicted proportions are, hence, usually much smaller than those of the raw proportions.

Figure A-1 shows the reduced design matrix and the vector of estimated model coefficients which together generate the predicted values of Table A-3. The predicted values are obtained by the matrix multiplication

$$\hat{P} = XB$$

where P is the vector of predicted A/R crash proportions, X is the reduced design matrix, and B is the vector of model coefficients. For example, the first predicted value is given by

$$\hat{P}_1 = .00050 + .00234 = .00284 \ ,$$

the second by

$$\hat{P}_2 = .00050 + .00234 + .00489 = .00773 \ ,$$

and so forth.

The predicted values shown in Table V can be seen to be quite close to the observed proportions for most of the subpopulations, especially for those with the larger frequencies (this is a result of the weighted least squares procedure which gives more weight to those subpopulations with smaller variances or larger frequencies). The standard errors of the predicted proportions in the last column of Table A-3 are considerably smaller than those for the observed proportions for most subpopulations. Thus, the predicted proportions give more precise estimates of the effects of the variables included in the model than do the observed proportions. This is especially true in the case of subpopulations with very small frequencies.

The same general approach to model development was followed for the other high risk groups. The design matrix and model coefficients for each of these high-risk groups are presented in Figures A-2 through A-7 and the related predicted values in Tables A-4 through A-9. In addition each figure also presents statistical parameters related to the fit of the model and the ratio of the predicted value of A/R crash involvement to the smallest. This ratio provides information on the range of predicted crash probabilities for subgroups within each high risk group. For example, as indicated in Figure A-1, the most extreme subgroup within the general population has an A/R crash probability 72 times greater than the probability of the lowest ranked subgroup.

In general all the models provided good fits to the data. All of the χ^2 due to error statistics were highly nonsignificant. The R^2 statistic was well above .90 for all the models except the DUI group where that value was .768.

Figure A-1. Design matrix and model coefficients - general population model.

$$
\begin{array}{r}
1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \\ 16
\end{array}
\begin{bmatrix}
1 & 0 & 1 & 0 & 0 & 0 & 0 \\
1 & 0 & 1 & 0 & 0 & 1 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 1 & 0 \\
1 & 0 & 0 & 1 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 0 & 1 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 1 & 0 \\
1 & 0 & 0 & 0 & 1 & 0 & 0 \\
1 & 0 & 0 & 0 & 1 & 0 & 1 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 1 \\
0 & 1 & 0 & 0 & 1 & 0 & 0 \\
0 & 1 & 0 & 0 & 1 & 1 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 1 & 0
\end{bmatrix}
\qquad
\hat{B} = \begin{bmatrix}
.00050 \\ .01546 \\ .00234 \\ .00849 \\ .01565 \\ .00489 \\ .01579
\end{bmatrix}
$$

χ^2 - due to model = 469.78 d.f. = 6

χ^2 - due to error = 7.63 d.f. = 9 ($p > .50$)

$R^2 = .984$

Ratio of largest predicted value to smallest = 72.0

Table A-3. General population group.

	Days S/R	Acc. Viol.	Sex	Reckless	Frequencies OAR	Frequencies 1+AR	Observed Proportions	Standard Error	Predicted Proportions	Standard Error
1.	N	N	M	N	77483	218	.00281	.00019	.00284	.00019
2.	N	N	M	S	2896	33	.01093	.00189	.00773	.00122
3.	N	N	F	N	72794	36	.00049	.00008	.00050	.00008
4.	N	N	F	S	538	2	.00370	.00261	.00539	.00122
5.	N	S	M	N	4509	40	.00879	.00138	.00898	.00131
6.	N	S	M	S	1030	16	.01530	.00379	.01387	.00169
7.	N	S	F	N	2821	2	.00071	.00050	.00050	.00008
8.	N	S	F	S	285	0	0	.00247*	.00539	.00122
9.	S	N	M	N	8762	143	.01606	.00133	.01614	.00131
10.	S	N	M	S	1603	53	.03201	.00433	.03193	.00416
11.	S	N	F	N	913	1	.00109	.00109	.00050	.00008
12.	S	N	F	S	64	1	.01539	.01527	.01629	.00434
13.	S	S	M	N	1595	58	.03509	.00453	.03111	.00318
14.	S	S	M	S	1093	36	.03189	.00523	.03600	.00323
15.	S	S	F	N	159	2	.01242	.00873	.01546	.00336
16.	S	S	F	S	52	1	.01887	.01869	.02035	.00341

*Standard error computed with 0 frequency replaced with 0.5

Figure A-2. Design matrix and model coefficients - 16-20 yr. old males model.

$$
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 0 \\
1 & 0 & 0 & 1 & 0 \\
0 & 1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 1 \\
0 & 1 & 0 & 1 & 0 \\
0 & 1 & 0 & 1 & 1 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 & 1 \\
0 & 0 & 1 & 1 & 0 \\
0 & 0 & 1 & 1 & 1 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 & 1 \\
0 & 0 & 1 & 1 & 0 \\
0 & 0 & 1 & 1 & 1
\end{bmatrix}
\qquad
\hat{B} = \begin{bmatrix} .00933 \\ .01664 \\ .02533 \\ .00855 \\ .02291 \end{bmatrix}
$$

χ^2 due to model = 185.40 d.f. = 4

χ^2 due to error = 10.14 d.f. = 11
($p > .50$)

$R^2 = .948$

Ratio of largest predicted value to smallest = 6.09

Table A-4. Males, 16-20.

	Total Days S/R	Total Viol.	Night Crashes	Night Viol.	Frequencies No AR Crashes	Frequencies 1+AR Crashes	Observed Proportions	Standard Errors	Predicted Proportions	Standard Errors
1.	N	N	N	N	61021	579	.00940	.00039	.00933	.00039
2.	N	N	N	S	123	0	0	.00571*	.00933	.00039
3.	N	N	S	N	3467	58	.01645	.00214	.01788	.00172
4.	N	N	S	S	28	1	.03448	.03388	.01788	.00172
5.	N	S	N	N	15444	258	.01643	.00101	.01664	.00098
6.	N	S	N	S	302	18	.05625	.01288	.03956	.00635
7.	N	S	S	N	2203	59	.02608	.00335	.02519	.00186
8.	N	S	S	S	107	7	.06140	.02248	.04810	.00647
9.	S	N	N	N	1787	53	.02880	.00390	.02533	.00187
10.	S	N	N	S	11	0	0	.06014*	.04824	.00622
11.	S	N	S	N	446	17	.03672	.00874	.03387	.00238
12.	S	N	S	S	11	0	0	.06014*	.05679	.00632
13.	S	S	N	N	3973	94	.02311	.00236	.02533	.00187
14.	S	S	N	S	529	26	.04685	.00897	.04824	.00622
15.	S	S	S	N	1078	49	.04348	.00608	.03387	.00238
16.	S	S	S	S	182	7	.03704	.01374	.05679	.00632

*Standard errors computed with 0 frequency replaced with 0.5.

Figure A-3. Design matrix and model coefficients - 21-24 yr. old males model.

$$
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 0 \\
1 & 0 & 0 & 1 & 0 \\
1 & 0 & 0 & 2 & 0 \\
0 & 1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 1 \\
0 & 1 & 0 & 1 & 0 \\
0 & 1 & 0 & 1 & 1 \\
0 & 1 & 0 & 0 & 0 \\
0 & 1 & 0 & 1 & 0 \\
0 & 1 & 0 & 1 & 0 \\
0 & 1 & 0 & 2 & 0 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 & 1 \\
0 & 0 & 1 & 1 & 0 \\
0 & 0 & 1 & 1 & 1
\end{bmatrix}
$$

$$
\hat{B} = \begin{bmatrix} .00698 \\ .01620 \\ .02240 \\ .01353 \\ .03184 \end{bmatrix}
$$

χ^2 due to model = 345.38 d.f. = 4

χ^2 due to error = 5.22 d.f. = 11 ($p > .90$)

$R^2 = .985$

Ratio of largest predicted value to smallest = 9.71

Table A-5. Males, 21-24.

	Total Days S/R	Reckless Viol.	Alcohol Viol.	AR Crashes	Frequencies: No AR Crashes	Frequencies: 1+AR Crashes	Observed Proportions	Standard Errors	Predicted Proportions	Standard Errors
1.	N	N	N	N	37415	516	.01360	.00060	.00698	.00031
2.	N	N	N	S	715	16	.02189	.00541	.02051	.00207
3.	N	N	S	N	252	5	.01946	.00862	.02051	.00207
4.	N	N	S	S	28	1	.03448	.03388	.03404	.00412
5.	N	S	N	N	7746	134	.01701	.00146	.01620	.00092
6.	N	S	N	S	399	23	.05450	.01105	.04804	.00674
7.	N	S	S	N	62	1	.01587	.01575	.02973	.00204
8.	N	S	S	S	19	1	.05000	.04873	.06157	.00690
9.	S	N	N	N	9764	154	.01553	.00124	.01620	.00092
10.	S	N	N	S	215	10	.04444	.01374	.02973	.00204
11.	S	N	S	N	3156	100	.03071	.00302	.02973	.00204
12.	S	N	S	S	354	12	.03279	.00931	.04326	.00399
13.	S	S	N	N	4966	112	.02206	.00206	.02240	.00192
14.	S	S	N	S	421	24	.05393	.01071	.05424	.00667
15.	S	S	S	N	1313	54	.03950	.00527	.03593	.00260
16.	S	S	S	S	299	19	.05975	.01329	.06777	.00681

Figure A-4. Design matrix and model coefficients - DUI model.

$$
\begin{array}{r}
1. \\ 2. \\ 3. \\ 4. \\ 5. \\ 6. \\ 7. \\ 8. \\ 9. \\ 10. \\ 11. \\ 12. \\ 13. \\ 14. \\ 15. \\ 16. \\ 17. \\ 18. \\ 19. \\ 20. \\ 21. \\ 22. \\ 23. \\ 24.
\end{array}
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 1 \\
1 & 0 & 0 & 1 & 0 & 0 \\
1 & 0 & 0 & 1 & 0 & 1 \\
1 & 0 & 1 & 0 & 0 & 0 \\
1 & 0 & 1 & 0 & 0 & 1 \\
1 & 0 & 1 & 1 & 0 & 0 \\
1 & 0 & 1 & 1 & 0 & 1 \\
1 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 1 \\
1 & 0 & 0 & 0 & 1 & 0 \\
1 & 0 & 0 & 0 & 1 & 1 \\
1 & 0 & 1 & 0 & 0 & 0 \\
1 & 0 & 1 & 0 & 0 & 1 \\
1 & 0 & 1 & 0 & 1 & 0 \\
1 & 0 & 1 & 0 & 1 & 1 \\
0 & 1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 1 \\
0 & 1 & 0 & 0 & 1 & 0 \\
0 & 1 & 0 & 0 & 1 & 1 \\
0 & 1 & 1 & 0 & 0 & 0 \\
0 & 1 & 1 & 0 & 0 & 1 \\
0 & 1 & 1 & 0 & 1 & 0 \\
0 & 1 & 1 & 0 & 1 & 1
\end{bmatrix}
$$

$$
\hat{B} = \begin{bmatrix} .02477 \\ .01507 \\ .01261 \\ .03353 \\ .00443 \\ .00610 \end{bmatrix}
$$

χ^2 due to model = 61.28

χ^2 due to error = 16.73
d.f. = 18 (p > .50

R^2 = .786

Ratio of largest predicted value to smallest = 5.11

Table A-6. DUI group.

	Age Level	Speeding Viol.	Days S/R	Reckless Viol.	Frequencies OAR crash	Frequencies 1+AR crash	Observed Proportions	Standard Error	Predicted Proportions	Standard Error
1.	1	N	N	N	243	5	.02016	.00893	.02477	.00256
2.	1	N	N	S	35	1	.02778	.02739	.03087	.00460
3.	1	N	S	N	437	27	.05819	.01087	.05830	.00981
4.	1	N	S	S	33	3	.08333	.04606	.06440	.01057
5.	1	S	N	N	100	2	.01961	.01373	.03738	.00381
6.	1	S	N	S	19	0	0	.03579*	.04348	.00504
7.	1	S	S	N	67	4	.05634	.02736	.07091	.01024
8.	1	S	S	S	17	3	.15000	.07984	.07701	.01081
9.	2	N	N	N	990	27	.02655	.00504	.02477	.00256
10.	2	N	N	S	106	4	.03636	.01785	.03087	.00460
11.	2	N	S	N	3010	96	.03091	.00311	.02919	.00242
12.	2	N	S	S	160	11	.06433	.01876	.03530	.00460
13.	2	S	N	N	309	13	.04037	.01097	.03738	.00381
14.	2	S	N	S	56	0	0	.01246*	.04348	.00504
15.	2	S	S	N	313	14	.04281	.01119	.04180	.00385
16.	2	S	S	S	44	3	.06383	.03566	.04790	.00514
17.	3	N	N	N	7200	111	.01518	.00143	.01507	.00134
18.	3	N	N	S	423	12	.02759	.00785	.02118	.00421
19.	3	N	S	N	21045	410	.01911	.00093	.01950	.00090
20.	3	N	S	S	578	15	.02530	.00645	.02560	.00418
21.	3	S	N	N	809	27	.03230	.00611	.02768	.00350
22.	3	S	N	S	86	3	.00371	.01913	.03378	.00495
23.	3	S	S	N	1028	40	.03745	.00581	.03211	.00351
24.	3	S	S	S	113	5	.04237	.01854	.03821	.00502

*Standard errors computed with 0 frequency replaced with 0.5

Figure A-5. Design matrix and model coefficients - three or more violations model.

$$
\begin{array}{r}
1\\2\\3\\4\\5\\6\\7\\8\\9\\10\\11\\12\\13\\14\\15\\16\\17\\18\\19\\20\\21\\22\\23\\24\\25\\26\\27\\28\\29\\30\\31\\32
\end{array}
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
1 & 0 & 0 & 0 & 0 & 0 & 1 & 0\\
1 & 0 & 0 & 0 & 1 & 0 & 0 & 0\\
1 & 0 & 0 & 0 & 1 & 0 & 1 & 0\\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 1\\
1 & 0 & 0 & 0 & 1 & 0 & 0 & 0\\
1 & 0 & 0 & 0 & 1 & 0 & 0 & 1\\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 1 & 0 & 0 & 0 & 0 & 1 & 0\\
0 & 1 & 0 & 0 & 1 & 0 & 0 & 0\\
0 & 1 & 0 & 0 & 1 & 0 & 1 & 0\\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 1 & 0 & 0 & 0 & 0 & 1 & 0\\
0 & 1 & 0 & 0 & 1 & 0 & 0 & 0\\
0 & 1 & 0 & 0 & 1 & 0 & 1 & 0\\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 1 & 0 & 0 & 0 & 0 & 1 & 0\\
0 & 1 & 0 & 0 & 0 & 1 & 0 & 0\\
0 & 1 & 0 & 0 & 0 & 1 & 1 & 0\\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 1 & 0 & 0 & 0 & 1 & 0\\
0 & 0 & 1 & 0 & 1 & 0 & 0 & 0\\
0 & 0 & 1 & 0 & 1 & 0 & 1 & 0\\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 1 & 0 & 0 & 1 & 0\\
0 & 0 & 0 & 1 & 1 & 0 & 0 & 0\\
0 & 0 & 0 & 1 & 1 & 0 & 1 & 0\\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 1 & 0 & 0 & 0 & 0 & 1 & 0\\
0 & 1 & 0 & 0 & 1 & 0 & 0 & 0\\
0 & 1 & 0 & 0 & 1 & 0 & 1 & 0
\end{bmatrix}
\qquad
\hat{B} = \begin{bmatrix}
.03946\\ .01739\\ .02255\\ .00590\\ .00342\\ .03393\\ .00674\\ .02834
\end{bmatrix}
$$

χ^2 due to model = 539.59 d.f. = 7

χ^2 due to error = 16.238 d.f. = 24 $(p > .75)$

$R^2 = .971$

Ratio of largest predicted value to smallest = 12.09

Table A-7. Three or more violations group.

	Age	Sex	Days S/R	AR Crashes	No Crashes	Frequencies 0 AR	1+AR	Observed Proportions	Standard Errors	Predicted Proportions	Standard Errors
1.	Y	M	N	N	N	7294	296	.03900	.00222	.03946	.00175
2.	Y	M	N	N	S	1090	47	.04134	.00590	.04620	.00226
3.	Y	M	N	S	N	54	2	.03571	.02480	.04288	.00316
4.	Y	M	N	S	S	320	21	.06158	.01302	.04962	.00305
5.	Y	M	S	N	N	3430	151	.04217	.00336	.03946	.00175
6.	Y	M	S	N	S	700	48	.06417	.00896	.06780	.00768
7.	Y	M	S	S	N	81	2	.02410	.01683	.04288	.00316
8.	Y	M	S	S	S	318	28	.08092	.01466	.07122	.00789
9.	Y	F	N	N	N	779	14	.01765	.00468	.01739	.00052
10.	Y	F	N	N	S	101	2	.01942	.01360	.02413	.00158
11.	Y	F	N	S	N	5	0	0	.12258*	.02082	.00274
12.	Y	F	N	S	S	8	1	.11111	.10476	.02756	.00264
13.	Y	F	S	N	N	214	3	.01383	.00793	.01739	.00052
14.	Y	F	S	N	S	37	0	0	.01873*	.02413	.00158
15.	Y	F	S	S	N	1	0	0	.38490*	.02082	.00274
16.	Y	F	S	S	S	9	2	.18182	.11629	.02756	.00264
17.	0	M	N	N	N	57509	1011	.01728	.00054	.01739	.00052
18.	0	M	N	N	S	4910	139	.02753	.00230	.02413	.00158
19.	0	M	N	S	N	882	50	.05365	.00738	.05133	.00426
20.	0	M	N	S	S	2051	124	.05701	.00497	.05807	.00415
21.	0	M	S	N	N	27881	644	.02258	.00088	.02255	.00085
22.	0	M	S	N	S	1862	55	.02869	.00381	.02929	.00172
23.	0	M	S	S	N	1384	39	.02741	.00433	.02598	.00261
24.	0	M	S	S	S	2426	80	.03192	.00351	.03272	.00252
25.	0	F	N	N	N	7391	46	.00619	.00091	.00589	.00088
26.	0	F	N	N	S	603	5	.00822	.01306	.01264	.00172
27.	0	F	N	S	N	50	3	.05660	.03174	.00932	.00282
28.	0	F	N	S	S	101	1	.00980	.00976	.01606	.00272
29.	0	F	S	N	N	1266	20	.01555	.00345	.01739	.00052
30.	0	F	S	N	S	93	4	.04124	.02019	.02413	.00158
31.	0	F	S	S	N	64	1	.01539	.01527	.02082	.00274
32.	0	F	S	S	S	95	2	.02062	.01443	.02756	.00264

*Standard error computed with zero frequencies replaced by 0.5.

Figure A-6. Design matrix and model coefficients - divorce model.

$$X = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix} \qquad \hat{B} = \begin{bmatrix} .00570 \\ .03571 \\ .01549 \end{bmatrix}$$

χ^2 due to model = 27.53 d.f. = 2

χ^2 due to error = 0.62 d.f. = 1 ($p > .25$)

R^2 = .978

Ratio of largest predicted value to smallest = 8.98

Table A-8. Divorce group.

	Alcohol Viol.	Reckless Viol.	Frequencies 0 AR	1+AR	Observed Proportions	Standard Error	Predicted Proportions	Standard Error
1.	N	N	7298	42	.00572	.00088	.00570	.00088
2.	N	S	493	10	.01988	.00622	.02118	.00600
3.	S	N	625	22	.03400	.00713	.03571	.00679
4.	S	S	126	9	.06667	.02147	.05119	.00869

Figure A-7. Design matrix and model coefficients - prison model.

$$X = \begin{bmatrix} 1 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 1 \\ 0 & 1 & 0 \end{bmatrix} \qquad \hat{B} = \begin{bmatrix} .0184 \\ .0602 \\ .0131 \end{bmatrix}$$

χ^2 due to model = 7.62 d.f. = 2

χ^2 due to error = 1.57 d.f. = 1 p = .21

R^2 = .829

Ratio of largest predicted value to smallest = 3.99

Table A-9. Prison group.

	Administrative	Age	Frequencies 0 AR	1+AR	Observed Proportions	Standard Error	Predicted Proportions	Standard Error
1.	N	≤ 30	703	22	.0303	.00637	.0315	.00630
2.	N	>30	1089	21	.0189	.00409	.0184	.00407
3.	S	≤ 30	75	9	.1071	.03374	.0734	.02028
4.	S	>30	67	3	.0428	.02419	.0602	.01983

Table A-10. Specific violations comprising general violation categories used in model development.

The following information concerns the specific driving offenses which are grouped under the more general violation classes used in the models. A violation under the general heading of speeding or reckless driving may be one of a number of specific offenses categorized under each heading. For example, one input for the model for 21-24 year old males is the number of reckless driving violations. Such a violation would be recorded on the driving record if he were convicted of negligent driving, illegal passing, manslaughter, or any of the specific, individual offenses that are included in the reckless driving category.

SPEEDING

203	Driving below minimum speed limit
210	Driving too fast for conditions
214	Failure to reduce speed
239	Exceeding safe speed
313	Speeding (at a speed under 55)
313	Speeding (at a speed over 55)
314	Speeding truck (at a speed under 55)
314	Speeding truck (at a speed over 55)
315	Speeding city limits (at a speed under 55)
315	Speeding city limits (at a speed over 55)

RECKLESS

224	Negligent driving
228	Scratching off
226	Passing on or over yellow line
401	Driving on wrong side of road
403	Hit and run--property damage
404	Illegal passing curve
405	Illegal passing hill
406	Illegal passing intersection
408	Reckless driving
409	Illegal passing (improper)
410	Hit and run
604	Racing (drag or spontaneous)
608	Hit and run--personal injury
609	Involuntary manslaughter
611	Manslaughter
612	Pre-arranged racing

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APPENDIX B

Computational Forms for Use in Economic Analysis

Form B-1 (Calculation of Treated and Untreated Crashes by Year)

YEAR 1

				Number of drivers-year 1	x	Prob. of A/R crash	=	A/R crashes	x	F. Sev. Fac.	=	fatal crashes (untreated)	x	F. Eff. Fact.	=	Fat. crashes (treated)
								A/R crashes	x	Inj. Sev. Fac.	=	Inj. crashes (untreated)	x	Inj. Eff. Fact.	=	Inj. crashes (treated)
								A/R crashes	x	PDO Sev. Fac.	=	PDO crashes (untreated)	x	PDO Eff. Fact.	=	PDO crashes (treated)

YEAR 2

Number of year 1 drivers	-	Number of year 1 fatals	=	Number of drivers-year 2	x	Prob. of A/R crash	=	A/R crashes	x	F. Sev. Fac.	=	fatal crashes (untreated)	x	F Eff. Fact.	=	Fat. crashes (treated)
								A/R crashes	x	Inj. Sev. Fac.	=	Inj. crashes (untreated)	x	Inj. Eff. Fact.	=	Inj. crashes (treated)
								A/R crashes	x	PDO Sev. Fac.	=	PDO crashes (untreated)	x	PDO Eff. Fact.	=	PDO crashes (treated)

YEAR 3

Number of year 2 drivers	-	Number of year 2 fatals	=	Number of drivers-year 3	x	Prob. of A/R crash	=	A/R crashes	x	F. Sev. Fac.	=	fatal crashes (untreated)	x	F. Eff. Fact.	=	Fat. crashes (treated)
								A/R crashes	x	Inj. Sev. Fac.	=	Inj. crashes (untreated)	x	Inj. Eff. Fact.	=	Inj. crashes (treated)
								A/R crashes	x	PDO Sev. Fac.	=	PDO crashes (untreated)	x	PDO Eff. Fact.	=	PDO crashes (treated)

YEAR 4

Number of year 3 drivers	-	Number of year 3 fatals	=	Number of drivers-year 4	x	Prob. of A/R crash	=	A/R crashes	x	F. Sev. Fac.	=	fatal crashes (untreated)	x	F. Eff. Fact.	=	Fat. crashes (treated)
								A/R crashes	x	Inj. Sev. Fac.	=	Inj. crashes (untreated)	x	Inj. Eff. Fact.	=	Inj. crashes (treated)
								A/R crashes	x	PDO Sev. Fac.	=	PDO crashes (untreated)	x	PDO Eff. Fact.	=	PDO crashes (treated)

YEAR 5

_____ Number of year 4 drivers − _____ Number of year 4 fatals = _____ Number of drivers-year 5 × _____ Prob. of A/R crash = _____ A/R crashes × _____ F. Sev. Fac. = _____ fatal crashes (untreated) × _____ F. Eff. Fact. = _____ Fat. crashes (treated)

_____ A/R crashes × _____ Inj. Sev. Fac. = _____ Inj. crashes (untreated) × _____ Inj. Eff. Fact. = _____ Inj. crashes (treated)

_____ A/R crashes × _____ PDO Sev. Fac. = _____ PDO crashes (untreated) × _____ PDO Eff. Fact. = _____ PDO crashes (treated)

YEAR 6

_____ Number of year 5 drivers − _____ Number of year 5 fatals = _____ Number of drivers-year 6 × _____ Prob. of A/R crash = _____ A/R crashes × _____ F. Sev. Fac. = _____ fatal crashes (untreated) × _____ F. Eff. Fact. = _____ Fat. crashes (treated)

_____ A/R crashes × _____ Inj. Sev. Fac. = _____ Inj. crashes (untreated) × _____ Inj. Eff. Fact. = _____ Inj. crashes (treated)

_____ A/R crashes × _____ PDO Sev. Fac. = _____ PDO crashes (untreated) × _____ PDO Eff. Fact. = _____ PDO crashes (treated)

YEAR 7

_____ Number of year 6 drivers − _____ Number of year 6 fatals = _____ Number of drivers-year 7 × _____ Prob. of A/R crash = _____ A/R crashes × _____ F. Sev. Fac. = _____ fatal crashes (untreated) × _____ F. Eff. Fact. = _____ Fat. crashes (treated)

_____ A/R crashes × _____ Inj. Sev. Fac. = _____ Inj. crashes (untreated) × _____ Inj. Eff. Fact. = _____ Inj. crashes (treated)

_____ A/R crashes × _____ PDO Sev. Fac. = _____ PDO crashes (untreated) × _____ PDO Eff. Fact. = _____ PDO crashes (treated)

YEAR 8

_____ Number of year 7 drivers − _____ Number of year 7 fatals = _____ Number of drivers-year 8 × _____ Prob. of A/R crash = _____ A/R crashes × _____ F. Sev. Fac. = _____ fatal crashes (untreated) × _____ F. Eff. Fact. = _____ Fat. crashes (treated)

_____ A/R crashes × _____ Inj. Sev. Fac. = _____ Inj. crashes (untreated) × _____ Inj. Eff. Fact. = _____ Inj. crashes (treated)

_____ A/R crashes × _____ PDO Sev. Fac. = _____ PDO crashes (untreated) × _____ PDO Eff. Fact. = _____ PDO crashes (treated)

YEAR 9

Number of year 8 drivers	–	Number of year 8 fatals	Number of drivers year 9	x	Prob of A R crash	A R crashes	x	F Sev Fac		fatal crashes (untreated)	x	F Eff Fact		Fat. crashes (treated)
						A R crashes	x	Inj Sev Fac		Inj crashes (untreated)	x	Inj Eff Fact		Inj. crashes (treated)
						A R crashes	x	PDO Sev Fac		PDO crashes (untreated)	x	PDO Eff Fact		PDO crashes (treated)

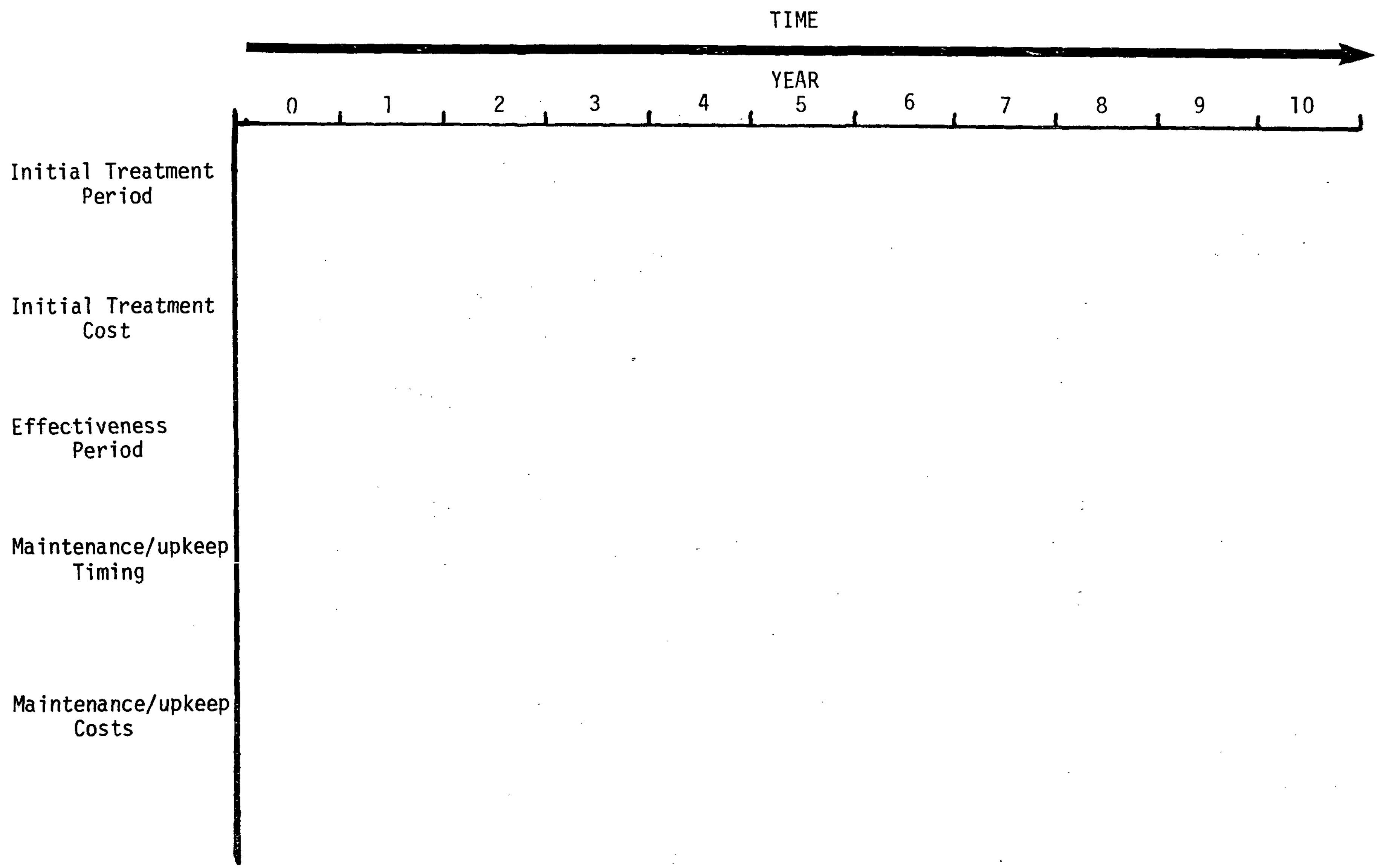
YEAR 10

Number of year 9 drivers	–	Number of year 9 fatals	Number of drivers year 10	x	Prob of A R crash	A R crashes	x	F Sev Fac		fatal crashes (untreated)	x	F Eff. Fact		Fat. crashes (treated)
						A R crashes	x	Inj Sev Fac		Inj crashes (untreated)	x	Inj. Eff Fact	=	Inj. crashes (treated)
						A R crashes	x	PDO Sev Fac		PDO crashes (untreated)	x	PDO Eff Fact.		PDO crashes (treated)

Form B-2. Predicted untreated and treated A/R crashes and crash reductions by severity.

	Predicted Crashes								
	Untreated			Treated			Crash Reductions		
Year	F	Inj.	PDO	F	Inj.	PDO	F	Inj.	PDO
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
				Totals =					

Grand Total of Crashes Reduced =



Form B-3. Treatment Process Scheme

Form B-4. (Calculation of Net Discounted Present Value.)

(1) Year	(2) Accident Reductions	(3) Accident Costs ($)	(4) = (2)x(3) Benefits ($)	(5) Initial Treatment Costs ($)	(6) Maintenance Costs ($)	(7) Inflation Factor	(8) = (6)x(7) Inflated Maintenance Costs ($)	(9) = (4)-(5)-(6) Net Cash Flow ($)	(10) Present Worth Factor at %	(11) = (9)x(10) Present Worth of Net Cash Flow ($)	(12) Cumulative Balance ($)
0 (1976)	0	0			0	1.000	0		1.000		
1	F- Inj.- PDO-	$140,586 11,515 437 Total	 = $								
2	F- Inj.- PDO-	$147,896 12,114 460 Total	 = $								
3	F- Inj.- PDO-	$155,587 12,744 484 Total	 = $								
4	F- Inj.- PDO-	$163,678 13,407 509 Total	 = $								
5	F- Inj.- PDO-	$172,189 14,104 535 Total	 = $								
6	F- Inj. PDO-	$181,143 14,837 563 Total	 = $								
7	F- Inj.- PDO-	$190,562 15,609 592 Total	 = $								

Form B-4. (Calculation of Net Discounted Present Value.)

(1) Year	(2) Accident Reductions	(3) Accident Costs ($)	(4) = (2)x(3) Benefits ($)	(5) Initial Treatment Costs ($)	(6) Maintenance Costs ($)	(7) Inflation Factor	(8) = (6)x(7) Inflated Maintenance Costs ($)	(9) = (4)-(5)-(6) Net Cash Flow ($)	(10) Present Worth Factor at %	(11) = (9)x(10) Present Worth of Net Cash Flow ($)	(12) Cumulative Balance ($)
8	F- Inj.- PDO-	$200,471 16,421 623 Total	= $								
9	F- Inj.- PDO-	$210,895 17,275 655 Total	= $								
10	F- Inj.- PDO	$221,862 18,173 689 Total	= $								

APPENDIX C

Computer Program for Economic Analysis

ECONOMIC ANALYSIS PROGRAM

This program (ECP) is written in PLI language and can be used at any installation with PL/I compiling facilities. It is designed to accept input data on cards, and can handle one or more treatment program analyses per run. To facilitate analyses of multiple treatments, a control character (the number '1') is punched preceding each set of data and a zero is punched after the last data set.

The input items are to be punched in the following order with one or more spaces in between each item.

1. Control character 1 data follows
2. Total treatment cost
3. Annual depreciation rate (e.g., 10% = .1)
4. Inflation factor (an annual rate of 5% would be entered as 1.05)
5. Effectiveness period (in years)
6. Starting year for study (i.e., year of treatment)
7. Class of study--not used at present--punch a "1"
8. Number of drivers in treatment group
9. Probability of A/R crash
10. Fatal Severity Factor
11. Injury Severity Factor
12. PDO Severity Factor
13. Fatal Effectiveness Factor (1 - fatal reduction percentage/100)
14. Injury Effectiveness Factor (1 - injury reduction percentage/100)
15. PDO Effectiveness Factor (1 - PDO reduction percentage/100)
16. Yearly Maintenance Cost - one entry for each year of effectiveness period (enter zeroes ('0') where no cost is incurred)
17. Control character - punch '0' if no other analyses follow--if additional problems follow--leave blank

If other analyses are to be done repeat the above data entry format.

```
ECP:    PROC OPTIONS (MAIN);

/*************************************************************************/
/*                                                                       */
/*                  DESCRIPTION OF INPUT VARIABLES                       */
/*                                                                       */
/*  THE INPUT VARIABLES SHOULD BE ORDERED AS FOLLOWS:                    */
/*                                                                       */
/*  YN--TELLS COMPUTER MORE DATA FOLLOWS OR NOT (1 FOR YES 0 FOR NO)     */
/*  IMP$--TREATMENT COST                                                 */
/*  ANNR--ANNUAL DEPRECIATION RATE  ( 10% = .1 )                         */
/*  INFF--INFLATION FACTOR  ( 1 + PERCENT INFLATION/100 )                */
/*  SVL--EFFECTIVENESS PERIOD                                            */
/*  STYR--STARTING YEAR FOR STUDY                                        */
/*  CLASS--CLASS OF STUDY (PUNCH 1)                                      */
/*  NDRIV--NUMBER OF DRIVERS                                             */
/*  PAR--PROBABILITY OF A/R CRASH                                        */
/*  FSF--FATAL SEVERITY FACTOR                                           */
/*  ISF--INJURY SEVERITY FACTOR                                          */
/*  PSF--PDO SEVERITY FACTOR                                             */
/*  FEF--FATAL EFFECTIVENESS FACTOR  (1 - % REDUCTION OF FATALS/100)     */
/*  IEF--INJURY EFFECTIVENESS FACTOR (1 - % REDUCTION OF INJURY/100)     */
/*  PEF--PDO EFFECTIVENESS FACTOR    (1 - % REDUCTION OF PDO/100)        */
/*  MAINT$(I)--MAINTENANCE COST (YEARLY FROM YEAR 1)                     */
/*        ENTER ZERO'S WHERE NO MAINT COST EXISTS                        */
/*  YN--CODE FOR END OF DATA (0 FOR NO MORE DATA, BLANK OTHERWISE)       */
/*                                                                       */
/*************************************************************************/

       DCL(I,K,YN) BIN FIXED;
       DCL (IMP$,NDRIV,PAR, SVL,STYR,CLASS,#FAT,#NFAT,#PDO,FEF,IEF,
            PEF,FSF,ISF,PSF,#ARCRASH,INFF,ANF,AFAT,APDO,AVB$,FR,IR,PR,
            NCF,PWNCF,CB,AC, FS,NF$,PDO$)FLOAT (16) INIT (0);
       DCL(L,J,CRFC,ACCPIFAT,SUMFR,SUMIR,SUMPR,SUMTOT,ANNR,PWF,
           #DRIV,CPIFAT)  FLOAT(16)
            INIT (0);
       DCL  MAINT$(0:20) FLOAT(16);     /*  MODIFY IF SVL > 20 */

   AGN: GET LIST (YN);
       IF YN=0 THEN GO TO OUT;
       GET LIST(IMP$,ANNR,INFF,SVL,STYR,CLASS,NDRIV,PAR,FSF,ISF,PSF,
               FEF,IEF,PEF);
       MAINT$=0;
       DO K= 1 TO SVL;
       GET LIST (MAINT$(K));
       END;

       #DRIV=NDRIV;
       AFAT,ANF,APDO,FR,IR,PR=0;
       PWF=1.0;
       CPIFAT=0;

       IF INFF = 1.0 THEN DO;
          CPIFAT=1.0;
          GO TO CAL;
```

```
ECP:     PROC OPTIONS (MAIN);



               END;

            IF STYR < 1982 THEN CPIFAT = 1.067;
            IF STYR > 1981  & STYR < 1987 THEN CPIFAT=1.057;
            IF STYR > 1986 THEN CPIFAT=1.047;
     CAL:
            F$ = 133637*((CPIFAT)**(STYR-1976));
            NF$ = 10946*((CPIFAT)**(STYR-1976));
            PDO$ =  415*((CPIFAT)**(STYR-1976));

   /*       PRINT ROUTINE FOR TABLE (A)                                      */

            PUT PAGE;
            PUT SKIP(5) EDIT ('ACCIDENT REDUCTION TABLE (A) : ',
                'PREDICTED UNTREATED AND TREATED A/R CRASHES AND ',
                'CRASH REDUCTIONS BY SEVERITY')
                (COL(5),(3) (A));
            PUT SKIP (3) EDIT ('STARTING YEAR : ',STYR)
                (COL(45),A,F(4));
            PUT SKIP(2) EDIT ('NUMBER OF DRIVERS : ',NDRIV)
                (COL(41),A,F(6));
            PUT SKIP(3) EDIT ('YEAR','CRASHES FOR UNTREATED DRIVERS',
                'CRASHES FOR TREATED DRIVERS','CRASH REDUCTIONS')
                (COL(5),A,COL(15),A,COL(50),A,COL(88),A);
            PUT SKIP(2) EDIT ('FATAL','INJURY','PDO','FATAL','INJURY',
                'PDO','FATAL','INJURY','PDO')
                (COL(16),A,COL(26),A,COL(40),A,COL(50),A,COL(60),A,
                 COL(74),A,COL(84),A,COL(94),A,COL(108),A);
            PUT SKIP(3);

    ACC:    DO I=0 TO SVL;
            #ARCRASH=PAR*NDRIV;
            #FAT=ROUND(#ARCRASH*FSF,4);
            #NFAT=ROUND(#ARCRASH*ISF,4);
            #PDO=ROUND(#ARCRASH*PSF ,4);

            IF I=0 THEN GO TO LOOP;
            AFAT=#FAT*FEF;
            ANF=#NFAT*IEF;
            APDO=#PDO*PEF;
            FR=#FAT-AFAT;
            IR=#NFAT-ANF;
            PR=#PDO-APDO;
    LOOP:
            IF I>0 THEN NDRIV=NDRIV-#FAT;
            SUMFR=FR+SUMFR;
            SUMIR=IR+SUMIR;
            SUMPR=PR+SUMPR;
            SUMTOT=SUMTOT+FR+IR+PR;

            PUT SKIP(1) EDIT (I,ROUND(#FAT,2),ROUND(#NFAT,2),
                ROUND(#PDO,2),ROUND(AFAT,2),ROUND(ANF,2),ROUND(APDO,2),
                ROUND(FR,2),ROUND(IR,2),ROUND(PR,2))
```

ECP: PROC OPTIONS (MAIN);

```
         (COL(7),F(2),X(3),(3) ((3) (F(9,2),X(2)),X(1)));
     END ACC;

     PUT SKIP(1) EDIT ((32) '-') (COL(79),A);
     PUT SKIP(1) EDIT ('TOTAL :',ROUND(SUMFR,2),ROUND(SUMIR,2),
         ROUND(SUMPR,2))
         (COL(70),A,COL(80),(3) (F(9,2),X(2)));
     PUT SKIP(2) EDIT ('GRAND TOTAL OF CRASHES REDUCED = ',SUMTOT)
         (COL(67),A,COL(101),F(10,2));


/*   PRINT ROUTINE FOR TABLE (B)                                       */
     PUT PAGE;
     PUT SKIP(5) EDIT ('ECONOMIC ANALYSIS TABLE (B)')
              (X(42),A);
     PUT SKIP(3) EDIT('STARTING YEAR',STYR)(X(45),A,F(5));
     PUT SKIP(3) EDIT
         ('NUMBER OF DRIVERS - - ',#DRIV,
          'PROBABILITY OF A/R CRASH - - ',PAR,
          'FATAL SEVERITY FACTOR - - ',FSF,
          'INJURY SEVERITY FACTOR - - ',ISF,
          'PDO SEVERITY FACTOR - - ',PSF,
          'FATAL EFFECTIVENESS FACTOR - -  ',FEF,
          'INJURY EFFECTIVENESS FACTOR - - ',IEF,
          'PDO EFFECTIVENESS FACTOR - - ',PEF)
         (COL(1),A,F(6,0),7(COL(1),A,F(8,4)));

     PUT SKIP(7) EDIT
              (' TREATMENT     MAINT  A/R CRASH REDUCTIONS   ACCI',
               'DENT   NET CASH  PWORTH  PWORTH OF  CUMULATIVE')
              (X(8),A,A);
     PUT SKIP EDIT
           (   'YEAR     COST        COSTS    FAT    NFAT   PDO    ',
               'BENEFITS      FLOW     FACTOR   NET CASH     BALANCE')
           (X(4),A,A);
     PUT SKIP EDIT
           (          '($)          ($)                              ',
            '($)          ($)        @',ANNR,'     FLOW $       ($)')
           (X(13),A,A,F(3,2),A);
     PUT SKIP(2);


     NDRIV=#DRIV;
     AFAT,ANF,APDO,AVB$,NCF,PWNCF,CB,FR,IR,PR=0;

FIG: DO I=0 TO SVL;
     #ARCRASH=PAR*NDRIV;
     #FAT=ROUND(#ARCRASH*FSF,4);
     #NFAT=ROUND(#ARCRASH*ISF,4);
     #PDO=ROUND(#ARCRASH*PSF ,4);

     IF I=0 THEN GO TO CONT;
     AFAT=#FAT*FEF;
```

```
ECP:     PROC OPTIONS (MAIN);


            ANF=#NFAT*IEF;
            APDO=#PDO*PEF;
            FR=#FAT-AFAT;
            IR=#NFAT-ANF;
            PR=#PDO-APDO;
            MAINT$(I)=(MAINT$(I))*(INFF**I);

   CONT:    AVB$=FR*F$+IR*NF$+PR*PDO$;
            NCF=AVB$-(IMP$+MAINT$(I));
            PWNCF=NCF*PWF;
            CB=CB+PWNCF;
            PUT EDIT (I,IMP$,ROUND(MAINT$(I),0),ROUND(FR,2),ROUND(IR,2),
            ROUND(PR,2),ROUND(AVB$,0),ROUND(NCF,0),ROUND(PWF,4),
            ROUND(PWNCF,0),ROUND(CB,0))
                    (R(F));

            IMP$=0;
            PWF=PWF/(1+ANNR);
            F$=F$*INFF;
            NF$=NF$*INFF;
            PDO$=PDO$*INFF;
            IF I>0 THEN NDRIV=NDRIV-#FAT;
            END FIG;

            L=ANNR;
            J=SVL;
            CRFC=(L*((1+L)**J))/(((1+L)**J)-1);
            AC=CRFC*CB;
            PUT SKIP (2) EDIT ('THE NDPV = $' ,ROUND(CB,0))
             (X(30),A,F(10));
            PUT SKIP(2) EDIT('THE AVERAGE ANNUAL CASH FLOW = $',
            ROUND(AC,0))
                  (X(30),A,F(10));
            GO TO AGN;

   F:       FORMAT(SKIP,X(5),F(2),F(12),F(9),(3)F(7,2),(2)F(11),F(8,4),
            F(11),F(12));
  OUT:      END ECP;
```