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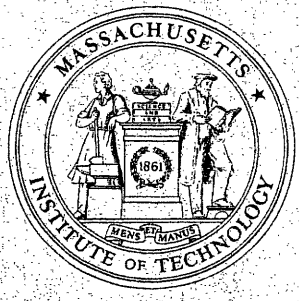

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Effect of Removing Accident Repeaters From the Road

by

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In newspaper editorials, public commentaries and the like, licensing authorities are often advised to solve the "accident problem" by taking the "nut behind the wheel" off the road. This paper uses six-year driver records of some 8,000 California drivers to estimate the reduction in accidents that would in fact occur if accident repeaters were removed from the road.*

1.1 Introduction

Popular notions concerning the role of chance and causal factors in automobile crashes suggest the existence of a basic attitude towards accidents and accident repeaters that considers the vast majority of accidents to be avoidable mistakes. These notions presume that all drivers are either "good" or "bad" and they manifest a belief that for nearly all accidents, one can find at least one "at fault" driver whose behavior was negligent or culpable, and who was thereby instrumental in "causing" the accident. Drivers who "cause" accidents are regarded as accident prone and are thought to be a small, identifiable group that is guilty of hazardous driving.

*By accident repeater we mean any driver involved in more than one accident during some specified period of time.

vastly overrepresented in accident statistics, and responsible for the "accident problem." Moreover, it is believed that good, safe drivers do not have accidents--at least they are not "responsible" for any.

This popular concept of accident proneness profoundly influences public and much expert opinion about problems concerning automobile accidents, driver licensing and the compensation of accident victims. As a result, careful consideration of the accuracy of this concept is important in determining the appropriateness of the fault system, of various licensing policies, and of automobile insurance rating schemes and cancellation practices.

In sincere efforts to address the root causes of accident losses, concerned commentators turn to statistics indicating the fraction of drivers involved in accidents, the accident rates of various groups of drivers, and the like. Statistics such as "15% of all drivers cause 50% of the accidents"[8] are often quoted to support the argument that the removal from the road of a small fraction of all drivers would result in a substantial drop in the total number of accidents.

However, one problem with making such inferences is the sensitivity of the statistics to the time period of the data on which they are based. After all, less than 1% of all drivers would account for <u>all</u> the accidents recorded during any <u>one week</u>! The 15% figure should be compared not with the 50% figure but with that fraction of all drivers that would be expected

to account for half of all accidents if all drivers were equally likely to be involved in accidents during the observed time period. Elsewhere, this author has examined such "15% cause 50%" figures in some detail.[10, 12] Statistics developed from the normal two or three-year accident records were found to be misleading in that they differed by less than 5% from the percentages of drivers that would be expected for the equally likely case. Further examination indicated that observed figures could be obtained even if drivers with average accident rates of at least one reported accident every two years accounted for less than one per cent of all reported accident involvements.

The above results demonstrated that low values for the observed percentages of drivers involved in accidents need not imply that the total number of accidents could be significantly reduced by removing a small fraction of the drivers from the road. However, they do not provide explicit estimates of the number of accidents that might be avoided over a specified period of time by a licensing "program" that ruled specific drivers off the road. This paper examines the prospects for reducing the total number of accidents in a more direct manner. In particular, California driver accident data are used to estimate the cumulative effect on the total number of accidents reported each year of a program which removes drivers from the road when they become involved in some minimum number of state-reportable accidents.

1.2 Previous Work

Previous research efforts have produced estimates of the effect of removing selected drivers from the road. In 1938 a study by Forbes[13] examined six-year data for 29,000 Connecticut drivers. Forbes divided the six years into two three-year periods and determined the number of accidents during the second three years that involved drivers with one and two accidents during the first three years. He found that drivers with at least one accident during the first three years accounted for only 4% of the accidents in the second period.

More recently, The Research and Statistics Section of the California Department of Motor Vehicles has made similar estimates.[6, 7] Drivers involved in at least two reported accidents during a two-year period accounted for 1.5% of the driving population and 3.3% of all accidents in a subsequent year.[6, p.2] Using two-year records of some 42,000 males, the research staff carried out a multiple linear regression of driver accident experience during a third year on such factors as a driver's age, marital status, geographic areas and prior accident and traffic violation experience.[7] The results indicated a significant but low correlation (R = 0.12). The drivers predicted by the equations to have accident rates in excess of 0.135 per year made up 6.4% (2,658) of the driver population and accounted for 13% (356) of the accidents reported during the next year.

The results of Forbes and the California group give some indication of the apparently limited impact that would result from such driver removal

programs. However, additional research is needed because of the following drawbacks to the Forbes and California type of analyses:

(1) the data in the Forbes study included only a fraction of all the actual accidents since reporting procedures at that time were much less extensive than they are today;

(2) data covering long time periods are rare and regression equations developed by the California Department of Motor Vehicles and by other researchers are typically based on three (or fewer) years of accident records. Such time periods are less than half the average time per driver between accidents. As a result, accident experience is a poor criterion to use in validating the regression equations and few drivers in the sample are involved in more than one accident during the time period that is examined;

(3) predictions based on the regression analyses are somewhat biased to the extent that the accident experience during the test year is used in developing the regression equations that predict the drivers with the highest risk. Thus, the selected drivers are expected to be overrepresented in the accidents recorded during the test year;

(4) neither the Forbes nor the California data were available in a form that facilitated year by year examination of individual driver records. As a result, the studies could not predict the cumulative effect over several years of actually operating a driver removal program;

(5) finally, such studies do not adjust estimates of the number of accidents avoided to account for effects due to multiple car accidents (75% of all accidents involve two or more vehicles.[7]) The results are developed from driver records that indicate <u>involvement</u> in

accidents. A single multiple-car accident would appear on the records of more than one driver. In such a case, it is not clear whether removing one or more of the drivers from the road would have avoided the accident in question.

The present research effort makes use of more recent data (1959-1968). These data contain only state-reported accidents* but do not include most accidents involving bodily injury. In addition, this report considers six yearly time intervals instead of Forbes' two three-year periods and the results are adjusted to account for enforcement problems and the fact that some accidents involve several drivers. The latter two considerations provide more realistic estimates of the effect of operating an actual license revocation program than have been obtained previously.

1.3 Driver Accident Data

Obtaining useful driver record data for a period of more than three years is quite difficult. Most Motor Vehicle Departments have purged records of information more than three years old, and insurance company records are not kept in a manner suitable for tabulation of accident data for a controlled sample of drivers. The author, through his association with the U. S. Department of Transportation's Automobile Insurance and Compensation Study, was priveleged to obtain a portion of some six-year driver record data from Dr. Albert Burg of U. C. L. A.'s Institute for Transportation and Traffic Engineering (ITTE). The data covered time periods ranging from November, 1959 through February 1968 and was

*The National Safety Council estimates that one-quarter to one-third of all accidents are reported to state authorities[17]

obtained at a cost of several hundred thousand dollars through the cooperation of ITTE, the California Department of Motor Vehicles (CDMV), the drivers involved, and a number of insurance companies. The data collection process and several statistical analyses of the data are given in various reports by Dr. Burg.[3,4] The data may be described briefly as follows:

(1) Drivers were sampled from queues in CDMV offices of individuals renewing driver's licenses. A total of 29,276 drivers were originally processed.

(2) Accident, citation, biographic and physiological information of various types was obtained for each driver from CDMV files, insurance company records and an interview and testing session with each driver. Data for drivers with fewer than three complete years on record were held for approximately one year and then processed.

(3) All information for each driver was encoded onto a minimum of six 80-column data cards and then stored on magnetic tape.

(4) After approximately three years had elapsed from the first data search, the records of 8,362 drivers were partially updated. For 7,842 of these drivers complete records over the second-three year period were available. Unfortunately no insurance company data was obtained for the second three-year period.

Several characteristics of the data are worth noting here. The data is unavoidably biased to the extent that motorists who are licensed and/or drive in California during short time periods (less than six consecutive

years) drop out of the six year sample. A driver whose license had been suspended would still be included, but a driver whose license had been revoked or who was killed in an accident would drop out. However, Burg compared age, sex and other driver characteristics in his sample with those of a 2% sample of all California licensed drivers and found no large differences.[3] Also, the degree of rarity of serious accidents--less than 1% of all reported accidents--indicates that any bias resulting from eliminating drivers involved in serious accidents from the population is small.

A second problem was that delays in processing the sampled drivers and the "purge files after three years" restriction of the CDMV resulted in some uncertainty and inaccuracy regarding the time-period associated with each driver. The ITTE data specified the date on which each accident occurred. However, the six-year period for each driver was not fixed but centered around one of two possible interview dates. As a result, an extensive amount of data analysis was required to appropriately define the number of accidents involving each driver during his six-year period. This analysis was done on two IBM 360/65 systems located at the Federal Highway Administration and at the M.I.T. Information Processing Center. The results are discussed in Appendix B of another report by the author[11] and indicated that uncertainties regarding the time-period had a negligible impact on the accident count during each "year."

The final data list developed from the ITTE data for use in this report was arranged in a simple form that is compact and yet permits one to

extract from it any desired combination of driver accident statistics. The data specifies the number of drivers out of the total driver population described by each possible six-digit combination (x(1), x(2),...,x(6)), where x(i) = the number of accident involvements during the i^{th} year, i = 1, 2, 3, 4, 5, 6. The 7,842 drivers in the ITTE data sample resulted in 144 such combinations. The combinations are listed elsewhere.[11, App. A]

This format provided an efficient means of storing the data and enabled one to rapidly extract data relating specific drivers to accidents in any of, in this case, six separate time periods. The number of drivers in the sample involved in a total of 0, 1, 2,... state-reported accidents during all six years is given in Table 1.

Table 1 - Six-Year ITTE Data

Number of Accidents	ITTE Data*	
	Number of Drivers	Percentage
0	5,147	65.63
1	1,859	23.71
2	595	7.59
3	167	2.13
4	54	0.69
5	14	0.18
5+	5	0.07
	7,842	100.00%

*The six year period ranged between November, 1959 and February, 1968.

2.1 Methodology

The procedure used to obtain unadjusted estimates of the accidents avoided by removing drivers from the road may be described as follows:

(1) Consider a hypothetical program that would review the accident records of all drivers at the end of each year and

(case 1) remove all drivers from the road who have been involved in at least X accidents (the cutoff number) since the first year the licensing program was begun, or

(case 2) remove all drivers from the road who have been involved in at least X accidents during that year (X = 1, 2, 3, . . .).*

(2) Determine the number of accidents in which each driver in the ITTE sample was involved during each of the six years.**

(3) Estimate the effect that operation of the program would have had on the 7,842 sample drivers during the six years by

(a) Examining each driver's record to determine in what year (if at all) he would have been removed from the road.

*Note that case 2 removes fewer drivers than does case 1 for any particular value of X.

**The 144 accident combinations described earlier provide this information.

(b) Counting any accident appearing on a driver's record during a year after he would have been removed from the road as an accident that is "avoided" during that year.

(4) Tabulate the total number of drivers that would have been removed from the road by the start of each year, and the number of accidents that would have been avoided during each year.

2.2 Unadjusted Estimates

A short Fortran program was used to carry out the above procedure for the 144 accident combinations that summarized the accident records of the 7,842 drivers in the ITTE sample. In presenting the estimates, several measures were possible depending upon whether current year results or running averages were considered. For example, the number of accidents avoided after four years of operating the program might be expressed either as the fraction of accidents that would have been avoided during the fourth year out of those that occurred during that fourth year, or as the total fraction of accidents that had been avoided out of all the accidents that occurred during the first four years. The approach that appeared most realistic (and, at the same time, indicated the largest possible fraction of accidents avoided) was to use the fraction of all drivers removed from the road prior to the start of each year and the fraction of accidents avoided out of those that would have occurred during that particular year.

Tables 2 and 3 present the results for cases 1 and 2, respectively, and for various accident cutoffs. The estimates are expressed as percentages--e.g., for case 1, 4% or 306 of the 7,842 drivers were involved in at least two accidents during the first three years. These 306 drivers accounted for 8% or 56 of the 679 accidents reported to involve the 7,842 drivers during the fourth year. The results for each year, then, are an estimate of the cumulative effect on that year's accidents of having operated the driver-removal program for the given number of prior years. The net effect after five years of operation is reflected in the "total" rows in each of the tables.

2.3 Interpreting the Results

As was mentioned in Section 1.2, several questions must be considered in determining whether the results of Tables 2 and 3 actually reflect the total number of accidents that might be avoided if such a driver-removal program were in fact implemented. In particular, one must consider (1) whether the implementation of such a program would, by itself, deter motorists who remain on the road from hazardous behavior, (2) whether drivers "removed from the road" would, in fact, stop driving and (3) whether a particular accident would have been avoided if one of the drivers involved had been removed from the road during a previous year. (Recall that multiple car accidents appear on more than one driver's record and, hence, the question of which driver to remove in order to avoid the accident is subtle.)

First, let us consider whether implementing such a program would produce a deterrent effect substantially greater than that of current licensing

Table 2 - Effect of Removing Drivers From the Road
(Case 1)

Percentage of Drivers Removed by the Start of Each Year
(out of 7,842 total)

Year	Percentage removed if X = 1	X = 2	X = 3	X = 4
1	0.00	0.00	0.00	0.00
2	7.35	0.43	0.01	0.00
3	13.61	1.85	0.29	0.04
4	19.60	3.90	0.73	0.11
5	25.18	6.08	1.36	0.32
6	30.44	8.43	2.22	0.61
Six-year Totals	30.44	8.43	2.22	0.61

Percentage of Accidents Avoided During Each Year

Year	Actual Number of Accidents	Percentage avoided if X = 1	X = 2	X = 3	X = 4
1	611	0.00	0.00	0.00	0.00
2	628	15.45	1.91	0.00	0.00
3	672	23.07	4.17	0.74	0.15
4	679	30.93	8.25	2.06	0.44
5	694	36.89	11.10	2.74	1.01
6	593	45.02	16.69	6.75	2.36
Six-year Totals	3,877	25.41	7.02	2.01	0.66

Note: Estimates were developed from the ITTE data. A driver was considered removed from the road at the end of the year in which his total number of accident involvements up to and including that year was at least X.

Table 3 - Effect of Removing Drivers From the Road (Case 2)

Percentage of Drivers Removed by the Start of Each Year (out of 7,842 total)

Year	Percentage removed if X = 1	X = 2	X = 3	X = 4
1	0.00	0.00	0.00	0.00
2	7.35	0.43	0.01	0.00
3	13.60	1.02	0.06	0.01
4	19.60	1.63	0.15	0.01
5	25.18	2.27	0.15	0.01
6	30.44	2.84	0.22	0.01
Six-year Totals	30.44	2.84	0.22	0.01

Percentage of Accidents Avoided During Each Year (out of 3,877 total)

Year	Actual Number of Accidents	Percentage avoided if X = 1	X = 2	X = 3	X = 4
1	611	0.00	0.00	0.00	0.00
2	628	15.45	1.91	0.00	0.00
3	672	23.07	2.38	0.30	0.15
4	679	30.93	3.24	0.74	0.44
5	694	36.89	5.04	0.43	0.00
6	593	45.02	7.25	0.84	0.34
Six-year Totals	3,877	25.41	3.30	0.39	0.15

Note: Estimates were developed from the ITTE data. A driver was considered removed from the road at the end of the year in which his number of accident involvements during that year was at least **X**.

programs. It is conceivable that accidents might be avoided not only as a direct result of removing specific drivers from the road, but also by altering the driving behavior and accident involvement rates of motorists who remain licensed as a result of the threat of possible license revocation. However, all state laws currently provide for license suspension and revocation in selected cases and/or at the discretion of the motor vehicle authority.[1] Hence, observed accident rates should already reflect this deterrent effect.

One might argue that the effect of existing programs is minimized since only a small portion of drivers actually have their licenses revoked. However, Oregon studies investigating the effect of warning letters and other threats to individual motorists report no significant improvement in the subsequent accident rates of these drivers.[14] In addition, behavioral and psychological considerations appear to discount the possibility of a significant deterrent effect resulting from an extensive driver removal program.[16]

Another indirect effect on the number of accidents might result if removing drivers from the road affects environmental factors such as the density of cars. However, traffic density and other environmental factors would not be expected to change appreciably unless a substantial number of drivers were ruled off the road--certainly a number too large to be politically feasible.

The second problem to be considered is that drivers whose licenses are suspended or revoked often continue to drive. In fact, studies by the California Department of Motor Vehicles indicate that as many as 68% of

motorists whose licenses have been revoked continue to drive.[5] Unless a driver-removal program were accompanied by rigid enforcement, the estimated number of accidents avoided would have to be reduced by a fraction of the order of one-half.

The third problem involves the fact that a single state-reportable accident might appear on more than one driver's record if the accident involved more than one vehicle. The California data include any reported accident involvement in each motorist's record as long as the driver was operating the vehicle at the time of the accident. In such a case it is not clear that an accident would have been avoided by removing only one of the drivers from the road.

The "driver fault" approach toward accident occurrence suggests one method of adjusting the estimates of Section 2.2 in a manner that circumvents this multiple car accident complication. According to the approach, one assumes that nearly all accidents involve one driver to whom primary responsibility for the accident may be assigned. It is this responsible driver who is "charged" with the accident and it would have been necessary to remove him from the road in order to have avoided the accident. By reviewing the circumstances surrounding each accident, the "innocent" involvements could be erased from a driver's record so that each accident would be recorded only on the record of the responsible driver. Had this procedure been applied to the records of the 7,842 drivers in the ITTE sample, new estimates of the accidents saved by operating a

driver removal program could be determined from the revised data using the same method that produced the results in Tables 2 and 3.

The difficulty with this approach is that any number of factors may have contributed to a particular accident and isolating a single factor as the cause is difficult and not always meaningful.[15, 16, 18] Nevertheless, the "fault" approach is recommended by those who argue that a small group of chronic accident repeaters cause most of the accidents and has been used to criticize the methods of Forbes and others who suggest that taking a few drivers off the road would not reduce the total number of accidents substantially. For these reasons, the approach is used here in adjusting the results of Section 2.2.

Driver accident data for a large random sample of drivers over a time period as long as six years and to which a consistent and unambiguous definition of fault has been applied is not available. For the 3,877 accidents recorded on the records of the 7,842 drivers in the ITTE sample, there is no indication of fault. However, by considering various extreme cases regarding which accidents would or would not be avoided, estimates of the range of possible effects of a driver-removal program, may be developed from the results of Tables 2 and 3.

2.4 Adjusted Estimates

In adjusting the estimates of Tables 2 through 3 primary emphasis is placed on accounting for the fact that a single accident may appear on several drivers records. Based on the discussion above, the indirect marginal deterrent and

environmental effects are assumed to be negligible, and adjustments for the fact that many restricted motorists continue to driver are considered separately after estimating the maximum possible fraction of accidents that might be avoided. The specific method for adjusting the estimated number of accidents avoided to account for the effect of multiple car accidents is detailed in the next several paragraphs.

First we note that few, if any, of the 3,877 accidents in the ITTE sample are likely to have involved more than one of the 7,842 drivers. To see this, assume that each accident involved two drivers* and that the drivers were randomly sampled from the approximately 10 million California motorists licensed during 1960 to 1968. The chance that any individual accident involved a second driver in sample would then be 8,000/10,000,000 and the number of accidents out of the total involving two drivers in the sample would have a binomial distribution with probability P = 8,000/10,000,000. Consequently, the probability that more than ten accidents would involve more than one driver in the ITTE sample is less than 0.001.** Thus, a negligible number of individual accidents are expected to involve more than one ITTE

*The National Safety Council figures indicate that 75% of all crashes involves at least two drivers and that multiple-car crashes involve an average of 2.05 drivers.[17]

**The probability of 0.001 is determined using a Poisson approximation to the binomial distribution.[9]

sample driver, but approximately 75% of them are expected to involve another driver not in the sample.

The "driver fault" approach toward determining which driver must be removed in order to have avoided an accident would be to assign primary "responsibility" to one of the drivers involved in any particular accident. An accident would be counted as an "avoided" accident if the responsible driver had been removed in a previous year. The total number of accidents out of the approximately 3,870 in the ITTE sample for which the driver in the sample was responsible would be approximately (3,870 x 0.25 + 1/2 (3,870 x 0.75)), or about 2,420. That is all the single car accidents (25% of the total) and about half of the multiple car accidents would still be recorded.

If this "driver fault" approach had been applied to the ITTE accidents before the estimates of Tables 2 and 3 had been calculated, the results might have been different. For lack of information, we cannot be sure which of the 3,870 accidents constitute the 2,420 that should be counted. Nevertheless, changes in the predicted percentage of accidents avoided will be determined primarily by the extent to which accident frequency and accident responsibility are correlated. By considering extreme amounts of correlation, one can estimate bounds on the magnitude of the changes.

If the number of accidents in which a driver is involved is uncorrelated with the fraction of his accidents in which he is "at fault," we would expect the results of Tables 2 and 3 to overstate the actual effect of a driver-removal program on the number of accidents. The reason is that

eliminating "innocent" accidents would reduce the total number of recorded accidents and would also decrease the number of drivers meeting the criterion each year. Since the assignment of fault and the number of accidents per driver would be uncorrelated, the new ratio of the number of accidents avoided to the total number of accidents recorded would be expected to be the same as for the ITTE results. However, fewer drivers would be removed each year. Removing fewer drivers, each with a similar proportion of accidents to be avoided, would imply a lower total fraction of accidents avoided.

On the other hand, one might argue that the more accidents a driver has had, the more likely it is that he was "responsible" for each of them. Thus, drivers with 2, 3, or more accidents would be expected to be responsible for more than half of their accidents.

In the case where any driver involved in any accident is removed from the road, it is unlikely that fault considerations would substantially alter the results. Since all drivers involved in accidents are removed, the only bias that might result from a correlation between fault and accident frequency would be that drivers more likely to be at fault would tend to be involved in accidents sooner. As a result, drivers who are involved in accidents during the first few years would be expected to have a better than 50% chance of being at fault in any future accidents. However, this increase in the number of accidents avoided as a result of this bias is offset by the fact that fewer drivers will be removed from the road if "innocent" accidents are not counted.

Thus, adjustments for multiple car accidents using the "driver fault" approach are not likely to change the estimated percentage of accidents that are avoided when all drivers involved in accidents are removed from the road.

In the cases where drivers involved in at least two accidents are removed from the road, fault considerations may be significant. The maximum possible fraction of accidents avoided would result if all drivers involved in at least the cutoff number of state-reported accidents are "responsible" for all their accidents. Such a situation is an extreme case, particularly when the cutoff number of accidents is 2 or 3, since it excludes the possibility of a driver being "innocently" involved in as many as the cutoff number of accidents.

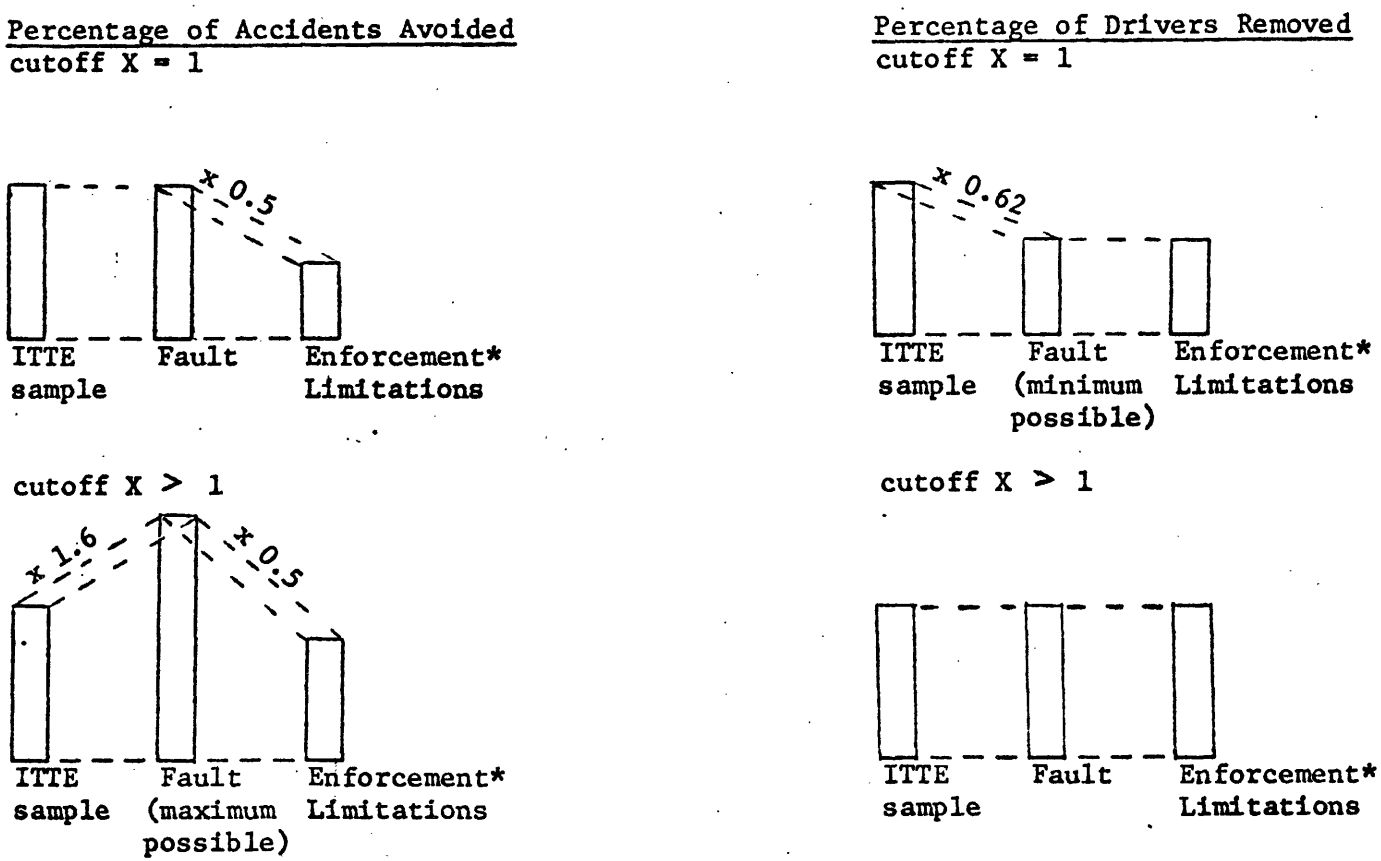
The estimated fraction of accidents avoided in this extreme case may be determined as follows. Since any driver meeting the criterion is assumed to be responsible for all past and future accidents, the ITTE figures for the fraction of drivers removed and for the number of accidents avoided per driver removed will apply. However, the total number of accidents will be reduced--since "innocent" drivers are no longer counted--by a factor of 2,420/3,870 as explained at the start of this section. Estimates of the maximum possible fraction of accidents saved in each year, then, are obtained by multiplying the previously obtained percentages of accidents avoided by 3,870/2,420 to account for the reduced number of accidents.

In making the above adjustments, we assume that all drivers "removed" from the road do, in fact, stop driving. Presently, licensing authorities "remove" drivers from the road by revoking their license (jail sentences and other alternatives are unwarranted treatment for any significant fraction of drivers). The California study cited above in Section 2.3 indicated that many motorists drove despite a revoked license. Unless imposed enforcement accompanied a driver removed program, this estimated maximum number of accidents avoided would have to be reduced by a factor of approximately two.

The approximations discussed above were incorporated into adjusted estimates of the percentages of accidents avoided and drivers removed. Figure 1 illustrates the adjustments made for fault, and enforcements considerations for each of the percentages. To aid the reader in comparing the various adjusted and unadjusted results, several graphs are also provided. The adjusted and unadjusted estimates are presented in Figures 2 and 3. Figure 2 considers the case where a driver is removed from the road when involved in a total of X accidents. Figure 3 considers the case where involvement in X accidents in one year is the criterion. The graphs indicate the percentage of drivers trained by the start of each year and the percentage of accidents avoided during each year as a result of the program's operation up to that time.

The lines connecting the small circles indicate the unadjusted estimates. The curves indicating the maximum possible percentage of accidents

FIGURE 1 ADJUSTMENTS FOR FAULT AND ENFORCEMENT CONSIDERATIONS



* Enforcement limitations refer to adjustments for fact that many motorists with revoked licenses continue to drive.

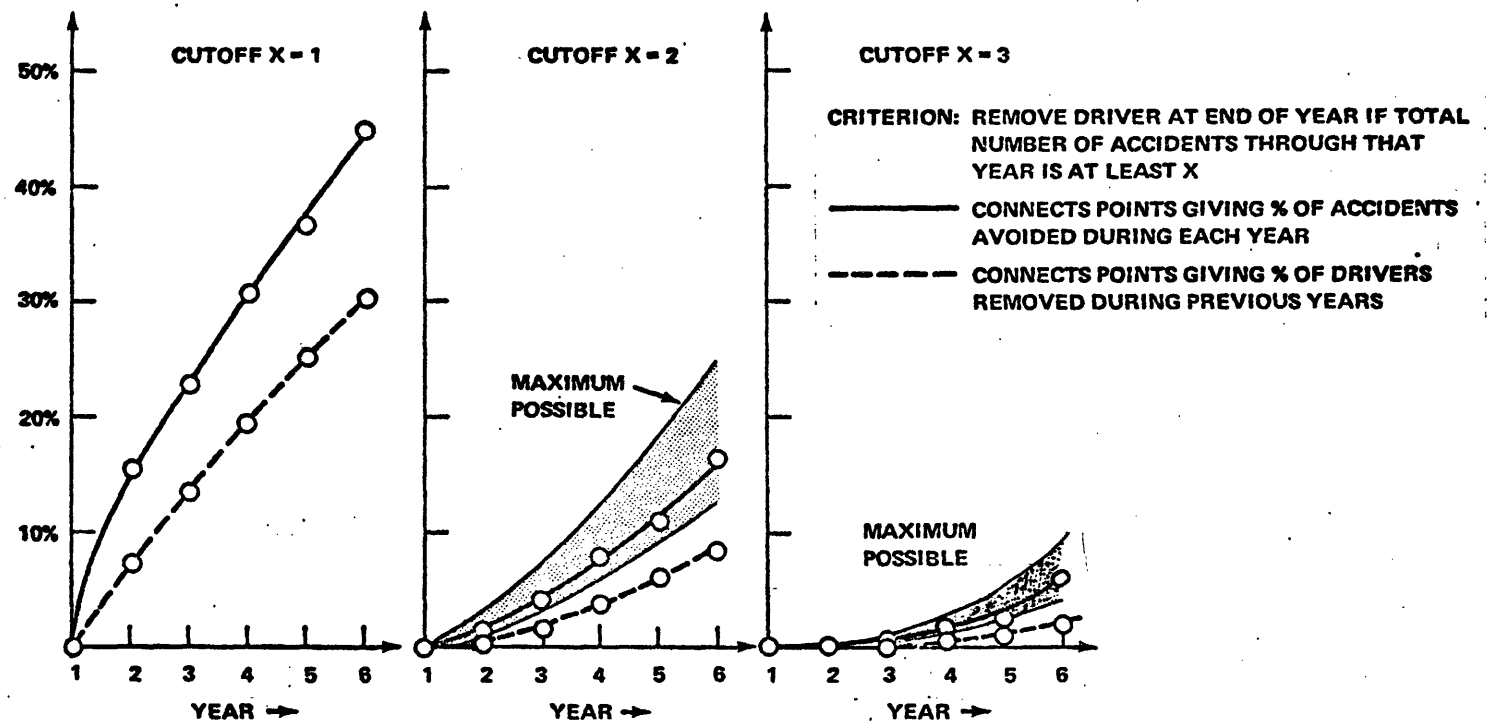


FIGURE 2 EFFECT OF REMOVING DRIVERS FROM THE ROAD (CASE 1)

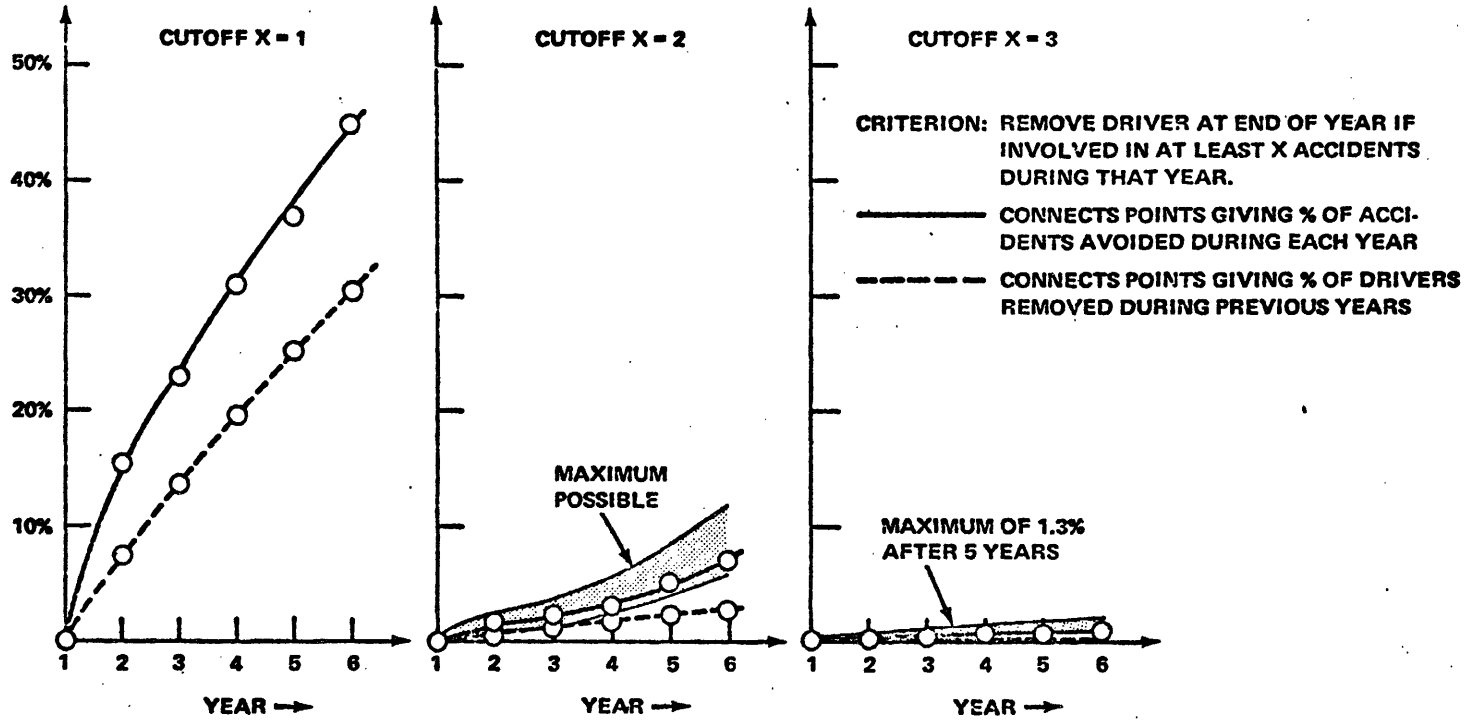


FIGURE 3 EFFECT OF REMOVING DRIVERS FROM THE ROAD (CASE 2)

avoided reflect the adjustments for multiple car accidents described earlier. The minimum percentage is liberally estimated as half the maximum to account for enforcement problems (half the unadjusted estimates would be a more conservative estimate).

For the case where any driver involved in accidents is removed from the road, so many drivers would have to be removed that implementation of the program could hardly be considered feasible. The curves do, nonetheless, indicate what fraction of accidents in any particular year involved drivers with accidents during the previous 1, 2, 3, 4, or 5 years. Shading the range of possible values for each curve in this case would have resulted in overlapping areas and was not done.

For those cases where accident repeaters are removed from the road (i.e., X = 2, 3, . . .), a lot fewer drivers are affected. However, only for case 1 and the X = 2 criterion is it conveivable that more than 15% of any one year's accidents could be avoided--and even then only after five years of operating the program. For this case, drivers are ruled off the road after their second accident involvement since the program's inception (year "1"). By the start of the fifth year, some 6% of the drivers would have been removed from the road and a maximum of 18% of that years accident might be avoided as a result. Expressed another way, at least four drivers would have to be removed for each accident avoided during the fifth year. If randomly selected drivers were ruled off the road approximately eighteen would have to be removed from each accident avoided (based on the adjusted number of accidents.)

The results look promising although perhaps not spectacular. Nevertheless, it must be remembered how these upper bounds were obtained. We assumed that everyone involved in two or more accidents was "responsible" for each of them and that no one was innocently involved in more than one accident during the five years. In addition, the driver removal programs are assumed to be completely effective in that the selected drivers are assumed to stop driving indefinitely.

For higher cutoffs (X = 3, 4, . . .) the "responsibility" assumptions used to obtain the upper bounds are more realistic. However, so few drivers meet the criteria that the percentage of accidents avoided remains small. The next section summarizes the analysis of sections 2.1 through 2.4 and presents several conclusions.

3.1 Summary and Conclusions

Taking the "nut behind the wheel" off the road has been a frequently recommended solution to the "accident problem." Its advocates argue that a small group of chronic accident repeaters account for most of the accidents and that the total number of accidents would drop substantially if these motorists were not permitted to drive.

Studies such as those by Forbes and the California Department of Motor Vehicles[7, 13] indicated only a small correlation between accident records of drivers during separate time periods. These results suggested that programs which remove accident repeaters from the road would not eliminate a major proportion of all accidents. However, such studies have

been critized as based on incomplete data over short time periods with no adjustments for fault considerations and multiple car accidents. In addition, it is difficult to translate the results of the studies into explicit estimates of the cumulative effect over several years of operating a specific strategy for revoking the license of selected drivers.

In this paper, recent six-year California driver accident data were used to estimate the cumulative effect on the total number of accidents reported each year of a program which removed drivers from the road when they became involved in some minimum number of state-reported accidents. The hypothetical program was assumed to review each driver's accident record at the end of each year and revoke the license of (or otherwise rule off the road) any driver involved in at least X accidents since the program's inception (case 1) or during the current year (case 2) for X = 1, 2, 3... . From the six-year data the number of drivers who would have met the revocation criterion at the end of each year was determined. Unadjusted estimates of the program's effect on the number of accidents in subsequent years were then obtained by counting the number of accidents during years two through six that involved drivers whose licenses would have been revoked by the "program" during a previous year.

These raw estimates (Tables 2 and 3) are based on more recent, comprehensive data than that of Forbes and on longer time periods than the California Department of Motor Vehicle studies. In addition the results provide explicit estimates of the percentage of accidents avoided during any

particular year as a result of operating specific license revocation strategic during the previous one through five years.

The difficulty with the raw estimates is that they are developed from individual driver records which, like the Forbes and California data, count accident involvements and (without cross reference) list a multiple car accident on the record of each involved driver. Since the data does not provide information about each recorded incident, it is not clear whether one or perhaps more accident involvements might have been avoided by removing one of the involved drivers from the road.

Skeptics argue that one needs data that records an accident only on the record of one responsible driver. Including "innocent" involvements, they say, hides the small group of drivers who cause most of the accidents and results in low estimates of the accidents avoided by operating a stringent, enforced license revocation program. No such data is available for large sample sizes. However, sections 2.3 and 2.4 of the paper developed a method for adjusting the estimates of Tables 2 and 3 to determine the maximum possible effect that such fault considerations might make. The adjusted estimates were presented in Figures 2 and 3. The results indicated that to avoid a truly large fraction of all reported accidents--say 50%--an enormous number of drivers would have to be ruled off the road--at least one out of every three drivers.

License revocation strategies with current enforcement practices could reduce the accident count by as much as 10% only if the licenses of

7% of the drivers were revoked. Liberal adjustments for fault considerations and an assumption that all selected motorists would actually stop driving, could conceivably result in a 20% savings in accidents from the same 7%. However, obtaining such an effect would require that a driver be ruled off the road when deemed responsible for his second accident and would take five years to be realized. If the small percentage of drivers most frequently involved in accidents were removed from the road, a large reduction in the total number of accidents would not result. Even when the most liberal adjustments for "driver fault" and multiple-car-accident considerations were made, the percentage of accidents avoided by removing the 2% or 3% of the drivers most frequently involved in accidents remained less than 10%.

The analysis presented here addresses the major criticisms of the work of Forbes, the California Department of Motor Vehicles and others who estimate the impact of accident repeaters on the total number of accidents. Specific estimates are provided for the effect of removing accident—involved drivers from the road. The results corroborate the conclusion of Forbes and the California group that the "normal" automobile driver accounts for most accidents and not a small group of chronic accident repeaters.

3.2 Acknowledgment

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References

1. Antony, Anthony, Suspension and Revocation of Drivers' Licenses, A Comparative Study of State Laws, Automotive Safety Foundation, Washington, 1966.

2. Arbous, A., and Kerrich, J., "Accident Statistics and the Concept of Accident-Proneness," Biometrics, December, 1951.

3. Burg, A., The Relationship Between Vision Test Scores and Driving Record: General Findings, Department of Engineering, U. C. L. A., June, 1967.

4. _____, Vision Test Scores and Driving Record: Additional Findings, Department of Engineering, U. C. L. A., December, 1968.

5. California Department of Motor Vehicles, Driving Under Suspension and Revocation, Sacramento, 1965.

6. _____, The California Driver Fact Book, Sacramento, 1969.

7. _____, The 1964 California Driver Record Study, Part 9, Sacramento, 1967.

8. Chrisman, C., address reported in National Underwriters (Fire and Casualty Edition), p. 51, November 8, 1968.

9. Drake, A., Fundamentals of Applied Probability Theory, McGraw-Hill, New York, 1967.

10. Ferreira, J., "Accidents and the Accident Repeater," Driver Behavior and Accident Involvement: Implications for Tort Liability, U. S. Department of Transportation, GPO-October, 1970.

11. _____, Quantitative Models for Automobile Accidents and Insurance, Report to U. S. Department of Transportation, GPO-September, 1970.

12. _____, Some Analytical Aspects of Driver Licensing and Insurance Regulation, M. I. T. Operations Research Center Technical Report No. 58, September, 1971.

13. Forbes, T. W., "The Normal Automobile Driver as a Traffic Problem," J. General Psychology, No. 20, 1939, p. 471-474.

14. Kaestner, N., et al, "Oregon Study of Advisory Letters: Effectiveness of Warning Letters in Driver Improvement," Traffic Safety Research Review, Vol. 11, No. 3, pp. 67-72, 1967.

15. Keeton, R., and O'Connell, J., Basic Protection for the Traffic Victim, Little, Brown and Company, Boston, 1965.

16. Klein, D., and Waller, J., Causation, Culpability and Deterrence in Highway Crashes, Department of Transportation, 1970.

17. National Safety Council, Accident Facts, Chicago, 1969.

18. U. S. Department of Transportation, "The Human Factor in the Highway Environment," Driver Behavior and Accident Involvement: Implications for Tort Liability, GPO-October, 1970.