Causes and Characteristics of Single-Car Accidents: Part I

HUGH S. PENN
Associate Research Analyst, Department of California Highway Patrol

Two considerations dictated the choice of single-car traffic accidents as a subject for study: (a) this type of accident has shown a steady increase in California, and (b) the driver at fault can be clearly identified.

This survey was designed to determine the approach to the study of accidents that casts the most light on causation. Part I uses the information available from accident reports. Part II will approach the subject via driver biographical data, and Part III through the application of a driver attitude test to a sample of single-car accident drivers. Means of predicting driver accident potential will be explored as the final phase of the study.

•THIS STUDY was initiated early in 1961 by Bradford M. Crittenden, Commissioner of the Department of California Highway Patrol. The immediate purpose of this project was to try to determine the reason for the gravity of the single-car accident problem in California. But other possible by-products emerged from the preliminary work.

The chief of these was the clear insight into accident causation which such a study might yield. In multi-vehicle crashes it is often difficult to fix responsibility for the accident. And even if this responsibility can be determined, elements of partial culpability on the part of the other drivers remain to cloud the issue. In most single-car mishaps, however, the responsibility can more easily be assigned. It would be expected on a priori grounds that the study of a group of such drivers would yield unequivocal information about accident causation.

Because accident statistics commonly embody a mixture of violations, factors and causes, a new set of cause categories was devised in the hope of identifying basic accident sources more clearly.

The cause data which made up the primary material of the study were the opinions and conclusions of the patrolman rather than the formal collision cause, which is usually coded by supervisory personnel. Thus, one possible source of variation was eliminated.

The causes employed herein are speed, drinking or drugs, drowsiness, faulty driving, adverse driving conditions, distraction inside vehicle, distraction outside vehicle, mechanical failure, medical problems, defective vehicle design, unknown vehicle, and miscellaneous. Since most accident causes are complexes of factors, the persons coding the reports were instructed to look for the most cogent factor in each report and to ascribe the accident to that factor ("cause"). For example, an accident involving primarily a lack of manipulative skill combined with high speed would be classed as stemming from faulty driving rather than speed.

The categories are in most cases self-explanatory, the possible exceptions being faulty driving, unknown vehicle, medical problems, and adverse driving conditions. The first grouping embraces accidents arising from lack of manipulative skill—e.g., steering the wrong way in a skid; and from mistakes in judgment—e.g., failure to recognize the end of a dead end street.

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"Unknown vehicle" refers to accidents said to be caused by another, unidentified driver, whose actions were responsible for the subject driver's coming to grief.

"Medical problems" includes accidents due to ill health or any medication except narcotics or stimulants.

"Adverse driving conditions" is intended to measure the driver's difficulties in coping with unusual situations in the driving environment. Heavy fog or a detour might illustrate this cause.

A few of the causes are apparently randomly distributed; hence, no correlation with the various characteristics studied is evident. For example, an accident caused by mechanical failure could happen equally well to men or women, at 4 a.m. as well as 4 p.m. These variables are measured only for their gross contribution to the accident totals.

This new cause system was devised on a purely empirical basis, with no previous work to furnish guidelines. Only one of the categories from the original schedule, defective vehicle design, failed to include a substantial number of cases (0.12 percent of the total). In the analysis, these cases were merged into the miscellaneous category.

A rough estimate of the sample size required to limit the theoretical error to 0.01 percent was made from the expression

$$Z = \frac{s}{\sqrt{n}} \tag{1}$$

indicating a sample of 1,500 cases.

But because the cost of extracting a larger sample of reports is negligible, and because a complex selection plan might engender confusion, it was decided to use two complete calendar months of single-car accident production. Each month's report was coded by different personnel so that any biases in classifying might be mutually canceling. An autumn month, September 1961, and a spring month, June 1962, were selected in order to include the effects of seasonal variation.

The number of cases used, about 5,200, is well beyond basic sampling requirements and should assure the validity of the findings as far as accidents are concerned. Some of the victim data proved to be insufficient.

The single-car accident problem is not a transitory one. In the areas of California served by the Highway Patrol, single-car accidents rose from 32 to about 40 percent of all accidents during the period 1950-1960. The single-car proportion has remained at the latter figure during 1961-1962, suggesting that this component of the accident total is approaching stability. Single-car fatals account for approximately 50 percent of fatal accidents of all types.

A comparison of the severity structure of single-car accidents with other motor vehicle accidents (excluding the noncollision, single car and pedestrian categories) shows that other accidents are made up of 65 percent property damage, as compared with 48 percent in the single-car group. Other motor vehicle accidents entail 33 percent of the injury severity, whereas single-car accidents show 49 percent injury. Fatalities occur with greater relative frequency in the single-car than in the other motor vehicle accident grouping—3.1 percent as compared with 1.5. It is a fair conclusion, therefore, that single-car accidents entail graver consequences for the principals than do other types.

Some aspects of the problem were not subjected to detailed analysis because of the absence of significant departures from general accident experience, because the same material was presented in other forms, or because the data were considered inadequate for valid conclusions. Perhaps the most substantial omissions were in the areas of speed and accidents by day of week. Speed was not studied in quantitative form because of the lack of accurate measurements. It appears in the study, however, in qualitative terms—an accident cause as evaluated by the investigating officer. No difference in the weekly distribution between single-car accidents and those of other types was found.

Three commonly used categories of accidents were grouped to form the single-car class: (a) overturned in roadway, (b) struck fixed object, and (c) ran off roadway. The original distributions were subjected to analysis of variance treatment, which showed homogeneity. On the strength of this test, the three types were combined.

The first grouping of the data to be undertaken was accident cause by degree of severity. On the assumption that a high proportion of property damage accidents may be taken as indicating a minor cause, it was noted that accidents attributable to mechanical failure, unknown vehicle, and miscellaneous factors would be classed as relatively innocuous. The common element in this complex appears to be that though the driver gets into trouble, he retains a considerable degree of control over the vehicle.

In cases where it can be assumed that this degree of control is less—in the case of drowsiness, adverse driving conditions, distractions inside vehicle, and medical problems (where unconsciousness may occur)—the relative incidence of fatal accidents is highest. The same observation applies to a lesser degree in the distraction inside vehicle, and drinking or drugs categories. Here, also, it may be theorized that the driver is sometimes either incapable of recognizing perils or is not looking at the road ahead. In many such cases, there would be no reduction in speed prior to impact and higher proportions of fatalities would be the logical result.

These data may be viewed profitably from another angle—that of the percentage of accidents resulting from each cause. This rearrangement sets forth the overall contribution of each cause to the accident grand total. Here it was seen that faulty driving, which is not usually considered in accident research, is the leading source of single-car crashes, accounting for 25.0 percent of the total, while excessive speed is a close second with 23.6 percent. Other major causes are drinking or drugs, 14.8 percent; and mechanical failure, 10.0 percent.

Another important field of inquiry is that relating to the sex of the driver. Comparing the driving performance of the two sexes with respect to accidents has been attended in the past by the difficulty of equalizing the exposure for the two groups. It is accepted that women's accident experience is much less than that of men. It is likewise recognized that fewer women drive and that their average annual mileage is lower than that of men. An attempt to take these factors into account was made in this study.

Male and female mileage and numerical representation in the driving population were found in earlier studies made by the California Department of Motor Vehicles. The use of these figures gave a multiplier which indicated that if the numbers of men and women drivers were equal and if they drove the same mileage, the women's accident record would be about 75 percent that of men. The same operation performed on comparable single-car data shows that the expected proportion of women's accidents to be 85 percent that of men.

It is seen that the percentages of male and female drivers in the study group are different from the percentages of drivers in all accidents investigated by the California Highway Patrol. The male percentages in the two groups were subjected to statistical tests and showed a significant difference at the 1 percent level. The proportion of male drivers in the single-car sample is significantly lower, and that of the female drivers significantly higher, than the corresponding population proportions.

If we examine accidents distributed in the table of causes according to the sex of the driver, certain interesting observations emerge. Significance tests were applied to accident causes by sex of driver data with the following results: the causes showing significant differences were speed, drowsiness, drinking, faulty driving, adverse driving conditions, and distraction inside vehicle.

In relative terms, therefore, it may be said that men show preferences for speed, drowsiness, and drinking. Women are weaker in the categories of faulty driving, adverse driving conditions (emergency situations in the driving environment), and distraction inside vehicle (stemming possibly from small children). The variables of mechanical failure, unknown vehicle, and miscellaneous could reasonably be regarded as random. Their nonsignificance is therefore not surprising. Distraction outside vehicle apparently also shares this characteristic.

These findings are consistent with the known psychophysical attributes of the sexes. Because of their greater strength and coordination developed by athletics and physical labor, men would be expected to find the management of the vehicle a relatively simple problem. Their more extensive driving experience would also tend to maximize operational skill. The opposite considerations apply generally to women.

On the other side of the coin, men's aggressiveness, daring, and rebelliousness make for reckless and often unlawful behavior. As women's psychological make-up embodies the obverse of these traits, they are comparatively low in accidents due to speed and drinking, and perhaps the aftermath of recreational activities—drowsiness.

Like sex, the age of the driver is strongly interwoven with several aspects of the single-car problem. In the course of the study the number of accidents produced by the various age groups were compared with the corresponding average annual mileages used previously.

Considering numbers of accidents alone, it is notable that more than 40 percent originate in the 15-24 age group. There is a steady decline through the 75 plus group. But if these percentages are related to the percentages of vehicle-miles driven by the various groups, a substantial change is evident. We may consider that if the number of accidents were commensurate with the mileage driven, the ratio of accidents to mileage would be 1.00. Accident experience greater than that which would be expected from mileage alone would give ratios larger than 1.00; experience less than that which mileage would produce would yield ratios smaller than 1.000. Calculations based on this hypothesis are presented in Figure 1.

The accident/mileage ratio in the 15-24 year group is about five times greater than 1.00. The ratio declines to approximately age 50 and then begins to rise. The 75 plus category is the second highest of the distribution. Six major causes by age group are shown in Figure 2.

It is clear that youth is the most dangerous period of life for single-car accidents, middle age the least dangerous, and old age intermediate between the two. Table 1

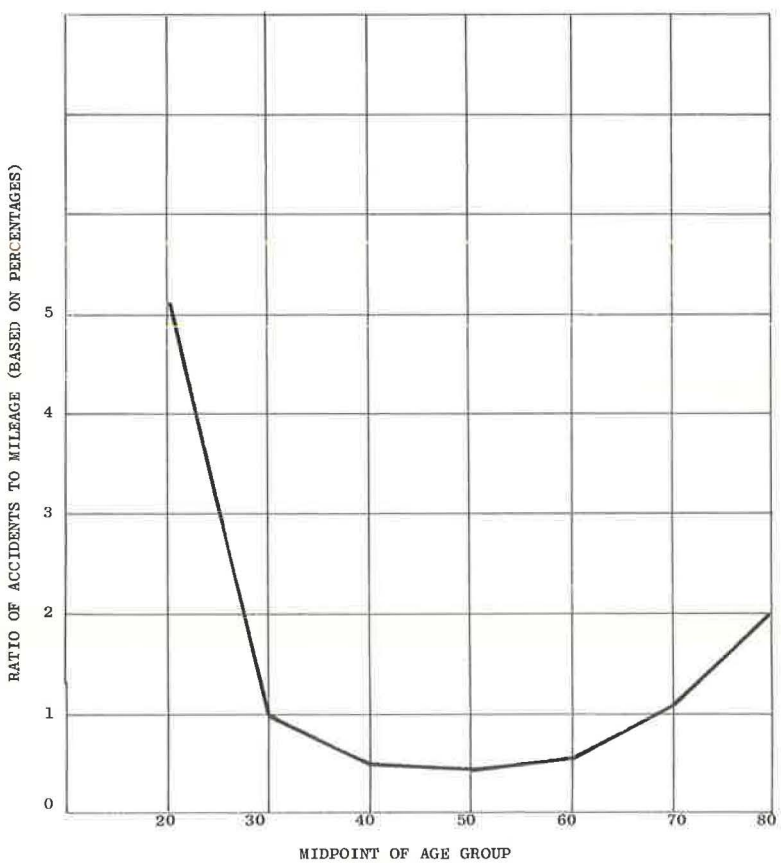

Figure 1. Single-car accident-mileage ratios by age of driver.

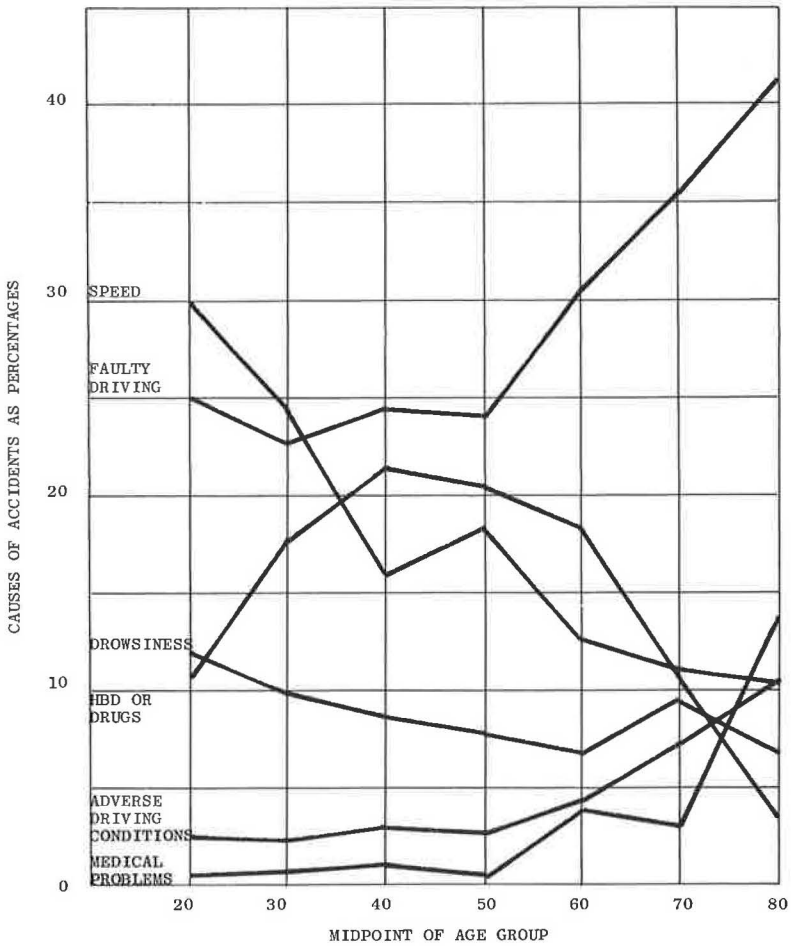

Figure 2. Selected causes of single-car accidents by age group of drivers.

summarizes data in a youth/middle-age/old-age breakdown giving the causes which appear to be age-connected.

In absolute terms, the 15-24 age group is unquestionably the most dangerous. If an efficient means of accident reduction could be found, its application to this age group should do the greatest good.

If accidents are studied in relation to numbers of drivers or to average annual mileage, the 65-and-over age groups are, by and large, proportionately worse than the others, as suggested in Table 1.

Vehicle occupancy also seems to be strongly linked to single-car accident causation. In the sample studied, about 3,700, or 71 percent, of the drivers involved in single-car crashes were traveling without passengers. On this basis it might be said that the chances of being involved in a solo accident are about 2.5 times greater for the unaccompanied than for the accompanied driver. It cannot be determined, however, whether this is so because there are more one-occupant cars on the road, or whether the accident frequency for such cars is actually higher.

Tests of significance applied to this aspect of the study data showed that speed, drowsiness, drinking, unknown vehicle and miscellaneous influences affect the solitary driver much more strongly than the operator of the multi-passenger car. Attention is claimed by the finding that the number of accidents caused by unknown vehicles is outstandingly high in cases in which the driver is by himself. It may be suspected that the

TABLE 1

Cause	Period of Life[a]		
	Youth	Middle Age	Old Age
Speed	H	I	L
Drowsiness	H	I	H
HBD or drugs	I	H	L
Faulty driving	I	L	H
Adverse driving conditions	I	L	H
Medical problems	L	I	H

[a]H = high, I = intermediate, and L = low.

"phantom" driver is often the scapegoat for the imprudent actions of the lone vehicular operator.

As would be anticipated, distractions inside vehicle account for a significantly high proportion of accidents involving multi-occupant vehicles. Possibly as a result of interaction with this variable, faulty driving is also shown to be of greater proportions in the "with others" class.

The temporal distribution of single-car accidents in relation to traffic is shown in Figure 3. It can be seen that from 7 a.m. to 6 p.m., the occurrence of accidents follows in a general way the fluctuations in traffic. From 7 p.m. to 6 a.m., accident production is much greater, relatively speaking, than traffic would warrant.

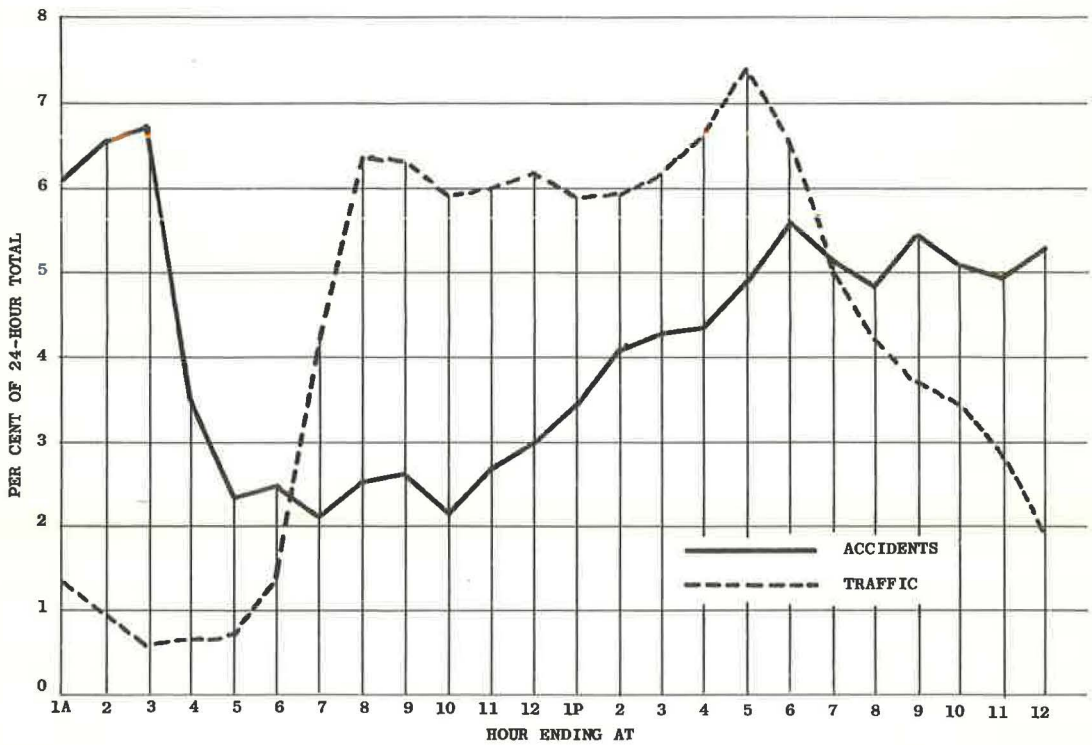

Figure 3. Vehicular traffic and single-car accidents by hour of day.

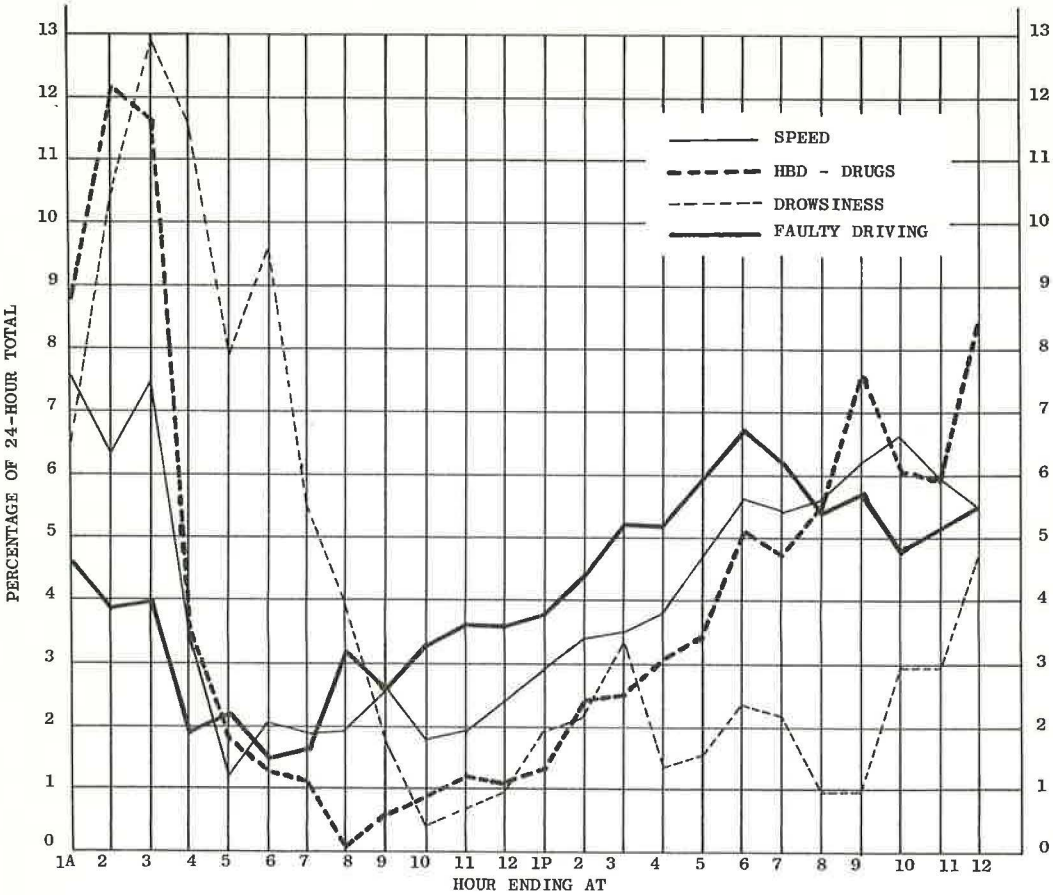

Figure 4. Selected single-car accident causes by hour of day.

Figure 4 presents a graphical portrayal of accidents due to major causes. It may be pointed out that drowsiness as an accident cause reaches the highest point of the day at 3 a.m., with another substantial peak at 6 a.m. Some periodicity throughout the day is evident; other rises take place at 11 a.m., 3 p.m., and 10 p.m.

Speed, being almost as prominent in the evening hours as in those of the early morning, seems to be a function of light traffic volumes. Faulty driving, on the other hand, appears to be distributed more in accordance with traffic, reaching its daily zenith in the 5 to 6 p.m. rush hour. It is the lowest of the four major variables in the dangerous 1 to 3 a.m. period. One might conclude that it is at least partially evoked by the stress and emergencies of heavy traffic.

The general similarity of several of these curves suggests the thought that they could be manifestations of only a few underlying factors. To test this supposition, the technique of factor analysis was applied to five of the variables which show marked patterns of hourly variation (speed, drinking, faulty driving, drowsiness, and distraction inside vehicle) and one which should be considered random—unknown vehicle. The factor containing the latter cause proved to be nondescriptive.

The application of factor analysis, which presupposes linear relationships among the variables studied, may be justified in this case by starting the daily distribution at 5 a.m. instead of 1 a.m. Conditions approaching linearity are then visible. Even so, substantial variances are involved, and the results of the analysis should be regarded only as approximate.

The preliminary correlations were made by the rank correlation method, each hourly total of the variables being assigned a number representing its position in the daily scale. Three factors were extracted from these six variables. The first accounted for 62.9 percent of the total variance, the second 29.5, and the third 7.6 percent. After rotation of the axes, the loadings on the third factor showed an indeterminate pattern. Accordingly, it was excluded from further consideration.

The first factor is heavily constituted of drinking (0.981), speed (0.966), and faulty driving (0.717). Since the major elements represent law violations, this influence in single-car accident causation might be termed "rashness."

The second factor is composed mainly of distraction inside vehicle (0.710), drowsiness (-0.688), and faulty driving (0.585). This grouping suggests lack of attention as a general cause. To connote both diversion of attention and drowsiness, the term "inattention" is proposed for this factor.

An interesting sidelight to the development of these factors is the appearance of faulty driving in both. It is expected that a variable which is highly loaded in one factor will be minimally loaded in the other. The moderately heavy weights of faulty driving in both factors lead to the inference that it partakes both of rashness and inattention.

An examination of the victim data of single-car crashes in general follows the findings of previous parts of the study. It would be expected that the casualty rate in multi-car collisions would be higher than that in single-car crashes because of the greater apparent exposure. But this expectation is not borne out by comparison of the two. For 1961, the deaths per fatal accident in single- and multi-car crashes were much the same, 1.24 as compared with 1.29, respectively. Injuries per injury accident were higher in single-car mishaps—2.24 as against 1.90. This equivalence may stem from the presumed higher speeds in single-car accidents and from differences in the events making up the chain of collision in the two cases. When two or more cars collide, much of the energy of the collision is absorbed. When a car runs off the road and rolls over, however, there is a strong likelihood of multiple contacts of the occupants with objects inside the car and of ejection. A head-on crash with a relatively immovable object also produces greater recoil because of abrupt deceleration, than does a collison with an object which is free to move.

Of the major causes studied in the survey, it was found that speed, drinking and drowsiness produce the highest proportions of deaths and serious injuries. Faulty driving, while contributing heavily to accident totals, is relatively low as a cause of death and injury.

Part II of the study will deal with biographical items—occupation, credit rating, and 3-yr driving records among others—derived from samples of approximately 600 drivers each.

Part III is concerned with the scores of Dr. Donald Schuster's Driver Attitude Survey administered to the same samples.

An overall aim of the investigation is the evaluation of data derived from these three sources. Which one, or which optimum combination of the three, sheds the most light on accident causation? It is possible that some of the measures coming out of this investigation may be efficacious in identifying and predicting accident potential in drivers.

Work on these phases of the project is underway at present.

Discussion

J. STANNARD BAKER, Traffic Institute, Northwestern University, Evanston, Illinois.— The idea of studying one-car accidents has much to commend it, especially when the objective is to try to determine contributing factors. Important problems are immensely simplified. The study which is the subject of these comments and the two proposed to follow it are, therefore, of great interest.

One-car accidents have been the subject of study before; for example, at Ohio State University as reported by Richard W. Bletzacker and Thomas G. Brittenham in "An Analysis of One-Car Accidents" (Highway Research Board 1958), and by these authors

and Robert F. Baker later in "A Study of One-Car Accidents." They have also been used for study of special aspects of accidents; for example, the present study of vehicle defects contributing to accidents by the Offical Swedish Council on Road Safety Research.

When one studies a report of research, he has to decide to what extent he can believe the data and conclusions presented. He has to do this on the basis of his own knowledge and experience. In this process, ideas develop and questions arise relating to the report and the research it represents. The following comments are some of the ideas and questions generated by study of "Causes and Characteristics of Single-Car Accidents."

Reason for Studying One-Car Accidents

The report implies that the reasons for studying one-car accidents are (a) their increase as a percentage of all, and (b) their severity.

We might ask whether this increase is due to some peculiarity of one-car accidents or to something else. One-car accidents are a much higher percentage of total accidents on limited-access and other divided roads. The percentage of travel on such roads in California probably has been increasing substantially in recent years. Therefore, may it not be that the increase in percentage of one-car accidents is due to improved roads rather than anthing peculiar to one-car accidents? If the road network is constant in quality, true one-car accidents theoretically should be proportional to the mileage traveled. A comparison by years of one-car accidents with miles driven should help us to know whether they are truly increasing in importance.

There is not a better and simpler reason than their apparent increase for studying causes of one-car accidents. In all true one-car accidents, there is no troublesome question of which traffic unit was "responsible" or of the interaction of two or more traffic units. The behavior resulting in injury or damage can therefore be imputed without hesitation to a specific car and driver. Contributing factors can then be deduced from available information with greater confidence.

Severity

How real is the apparently greater severity of one-car accidents? Is there anything about them that makes them more severe or could some or all of the greater severity be the result of less complete reporting of minor single-car accidents? In multi-car accidents, there are approximately twice the number of people involved per accident and, therefore, a much greater chance of some one person being injured or killed. This would lead us to expect greater severity for multi-car accidents. How then, do we explain the higher percentages of fatal and injury accidents among one-car accidents?

We can be sure that fatal accidents are completely reported. But there is good reason to believe that minor one-car accidents are much less fully reported than multiple-car accidents. When two or more cars are involved in even a very minor accident, it will be reported so as to be on record for claim settlement purposes. But a driver in a one-car accident of the same severity often may not take the trouble to report; it would only be an unwanted encumbrance on his driving record. Furthermore, in one-car accidents where there is no chance of filing claims for injuries, fewer injuries will be reported, especially fewer Class C injuries. For two years, damage to frequently repaired guardrails, posts and trees at a sharp right-angle turn in a state highway were regularly noted by the writer. This damage suggested that about 20 cars had suffered sufficient damage by collision with fixed objects to produce reportable one-car accidents. Yet official records showed only three acidents at this point, all involving two cars and none with injury. Can we not, therefore, question the conclusion that "drivers in 'solo' crashes are exposed to greater risk?" Might it not be equally possible to conclude "minor 'solo' crashes are less likely to come to the attention of the authorities?" Would it not be likely also that on rural roads reporting of minor one-car accidents would be less complete than in built-up areas because bypassers and those living nearby would be fewer and less likely to report and because patrolling is less frequent and so police are less likely to come on the accident without being summoned?

The surprising differences shown between single-car and other accidents of deaths per fatal accident and injuries per injury accident can perhaps best be accounted for by less need to report injuries in one-car accidents in which possible damage suits are far less likely to be involved. There seems to be no other really good explanation.

Definition of Single-Car Accident

The definition of single-car accidents as "those in which the sequence of events starts with a driver losing control of his vehicle" seems to be a theoretical one rather than the definition actually used. Was an actual determination made in each case that the driver "lost control," whatever that means? If so, how and by whom was the determination made? Actually three types of accidents seem to have been accepted as representing and defining single-car accidents: (a) "running off roadway" (Does this mean road or roadway as defined in "Manual on Classification of Motor Vehicle Traffic Accidents?"); (b) striking a fixed object; and (c) overturning in the roadway.

Classification by these types is simple and reasonably reliable. For the purpose of this study these groups would seem to be adequate.

But these three types of accidents should not be equated with true one-car accidents. True one-car accidents should surely not include those in which a vehicle runs off the road or hits a fixed object to avoid striking another vehicle. The fact that 5 percent of the single-car accidents are attributed to "unknown vehicle" suggests at least that a small percentage of the accidents in this study are not true one-car accidents.

Collisions with properly parked vehicles as well as with fixed objects and other objects should also be included among one-car accidents. The addition of "collision with parked vehicle" as a type of accident in the most recent edition of the "Manual on Classification of Motor Vehicle Traffic Accidents" will enable these to be separated from other two-car accidents and included with one-car accidents.

If leaving the road and crossing a narrow median to collide with an oncoming vehicle in the opposite direction is a true one-car accident—as it would be by using existing accident classifications—why would not crossing a barrier line to encroach on the path of an approaching vehicle also be a one-car accident? Then how about crossing a center line? Thus, there are real problems in defining one-car accidents. One should be careful in a definition to indicate exactly what are actually accepted and used as single-car accidents as contrasted with what might be theoretically included.

Cause Classification and Determination

The problem of classifying "causes" is formidable, especially if this has to be done from information supplied by others. It is obviously simpler for statistical treatment to have only one cause for each accident. Hence the idea of a "precipitating incident" which "triggers" the accident is convenient. But it is not easy to set up rules for determining which of several apparently co-existing factors triggered the accident. Such rules have almost built-in bias. For example, if preference is given consciously or unconsciously to law violations, some other factors are sure to be suppressed. Eleven "causes" including "miscellaneous" are used. These are used as though they were mutually exclusive. But are they really so? For example, do "drinking or drugs" not often contribute to accidents by way of "faulty driving?" Can drinking not also contribute through speed? Speed is one of the categories for which the title is "in most cases self-explanatory." Yet all accidents involve some speed. One wonders what speed is related to. The speed limit? Too fast for conditions? Is it determined by accident severity or by possibility of taking successful evasive action?

Under the circumstances one cannot avoid a definitely uneasy feeling that some, perhaps much of the variation among "causes" may be the result of methods of data reporting and interpretation. This would be especially true of minor differences.

Some Special Problems

Examining the data, therefore, raises some interesting questions that one would like to have answered.

For example, if mechanical failure and medical problems are both single "precipitating" conditions (they can hardly be called incidents), why do accidents caused by medical problems seem to be so much more severe than those due to mechanical failure? Surely, a driver would have more forewarning of a medical problem than of a mechanical failure. Presumably, except in rare cases, medical problems would be less difficult to cope with. Could it be that some medical problems were really causes of death and "injury" than causes of the accident? What would these figures look like if injury and death of drivers only were considered? Or passengers only if car occupancy were known well enough?

"The number of accidents caused by unknown vehicles is outstandingly high in cases in which the driver is by himself." Can this be a result of accident reporting? Information about the unknown vehicle in one-car rural accidents is almost invariably the report of a driver. It explains his accident. Would he not be more likely to explain it as an "unknown vehicle" when alone than when there were others in the vehicle who might not corroborate his report? The single occupant could never report this condition if the accident were fatal, but he would be highly likely to do so in a property-damage collision. Would this not possibly explain why, for unknown vehicles, the percentage of property damage accidents is highest for any cause and the percentage of fatalities is lowest?

What percentage of the one-car fatal accidents involved no passengers is not stated, but about 70 percent of all one-car accidents did so. Therefore, it can be assumed that in half or more of the fatal one-car accidents there would be no survivor to tell about the accident. Then in more than half of the one-car fatal accidents there would be virtually no way of knowing it if the "cause" was drowsiness, distraction inside, distraction outside or unknown vehicle. It would be difficult, in many cases, to detect drinking, faulty driving, mechanical failure, and medical problems. Consequently, underclassification would result in these categories and overclassification in speed, miscellaneous and perhaps adverse driving conditions. Many serious injury accidents would present the same difficulty because of loss of memory. Consequently, the relative seriousness of accidents related to various causes may be modified appreciably by the limitations of sources of information.

Of 164 fatal accidents, 39—or 24 percent—were attributed to drinking or drugs. Presumably nearly all were drinking. On the accident reports a certain number were indicated as having been drinking. We do not know in how many of these cases drinking was determined to be the "trigger" event and in how many this was rejected in favor of one of the other eleven categories. However, autopsies of drivers killed in accidents in New Jersey showed 58 percent had been drinking, Delaware autopsies showed 39, Maryland 62. In New Jersey, accident responsibility was "indicated" for 85 percent of the drivers who were alcohol positive on autopsy. It would seem, therefore, that on the basis of autopsies about half of the accidents might be considered as "caused" by drinking. This is twice the number indicated in the report. Does this mean that in perhaps a half or a third of the cases in California in which there was an indication that the driver had been drinking, those who classified the accident decided some other factor "triggered" the event? Does it mean that in California a great many fewer drivers had been drinking than on the East Coast? Or does it mean that reports of one-car accidents, like most accident reports, apparently do not detect and report nearly all of the drivers who had been drinking?

Possible Testing of Data for Accuracy of Reporting

We would like to have methods for testing the reliability of original data as easily applied as those for testing the significance of statistical inferences.

Lacking them, methods of collecting and interpreting the data must be carefully evaluated to appraise the value of conclusions drawn from them by statistical manipulation!

Examination of the conclusions in the light of past experience, logic, and other similar studies, as has been done above, may also suggest certain weakness in the original data.

Special comparisons can help test the data indirectly. A few of these appear in the report but when a "curious consideration emerges," deficiencies in original data are not suggested as a possible explanation.

An example of such a test will illustrate. Some of these "causes" would be randomly distributed with vehicle travel and not affected by time of day. The best example of this would be mechanical failure. There is no important logical reason why vehicles should fail more at night than by day or in the rush hour than at other times. Therefore, the hourly distribution of mechanical failures ought to correspond closely to hourly distribution of traffic. All single-car accidents were compared with volume of traffic by hour of day (Fig. 3), but this includes important causes, such as drinking and drowsiness, which our common experience tells us are influenced indirectly by hour of day. If percentage of mechanical defects by hour of day had approximately the same distribution as traffic volume, one would feel some confidence that data collection methods were reliable. However, if the distribution of mechanical defects as causes of accidents corresponded more nearly to that of drowsiness or had been drinking, one would be suspicious. Perhaps mechanical defects are reported to explain circumstances that the reporting driver would consider more culpable: intoxication and falling asleep.

Uses of Data

Data in this report do, in many respects, usefully confirm data from other sources. The distribution of accidents by age of driver corresponds well with data on all accidents from other sources indicating that age is not a significantly different factor in one-car accidents than in others.

When traffic-accident research reports are received by those responsible for some phase of preventing accidents, they are examined for clues as to what might be done differently as a result of new knowledge from the report. Research reports individually are rarely the basis for new lines of activity. This is no exception. But taken with other people's reports accumulating over many years, this will add to a better understanding of accidents and consequently of their prevention.

GENE MILLER, National Safety Council.—The opening remarks in the "Discussion" indicate good general knowledge of the importance of the single-car accident problem in terms of frequency, severity, and trend, and the analysis of the data, including preparation of charts and tables generally is excellent.

In any study of this kind, though, the conclusions should be of paramount importance. But the conclusions can be no more reliable than the data which are analyzed, and it is in this area that a question seems appropriate.

The report contains no statement bearing on the reliability of the basic data. There is a statement that the "preparatory work was a Patrol project," and that reclassification of the report "was done in the Patrol's Operational Planning and Analysis Division."

One introductory statement concedes that interpretation of the same data by different persons usually varies. And another statement concedes that biases in classifying probably do occur, and as a possible way of correcting for this, "each (of two) month's reports were coded by different personnel so that any bias in classifying might be mutually canceling." It would seem better to have set up controls to insure uniformity in classification.

The reputation of the California Highway Patrol apparently is offered as assurance of reliability of the data, and while it is quickly admitted that some of the best motor vehicle data now available are collected by the California Highway Patrol, it would still seem that a special analysis such as this one should contain evidence of unquestioned reliability and validity in the basic data. Instead, validity of the data is suggested in at least one place in the report because it confirms "a priori expectations."

It is even possible that the analysis should have been the second part in the series of studies, and that the first part should have been a determination of the reliability of

the data, or if necessary, the design and collection of new data under conditions sufficiently controlled to insure their validity and reliability.

The report states that "a new set of cause categories was devised in hope of identifying accident causes more clearly," and further, that "this new cause system was devised on purely a empirical basis, with no previous work to furnish guidelines." Again, a test or study of this new "cause system" might well have been the subject of the first in a series of studies, but apparently the study under review includes both some testing of the new cause system, as well as an analysis of data collected for the first time under the system.

Frequently in the report, references to the data include statements such as: "Statistics are not available," "If more data were available," "Recent data are not available," "It is assumed," etc.

This may appear to be undue concern over the basic data, but unless such data truly reflect the accident situation, and are properly identified and classified, the most advanced and precise analytical methods can only produce questionable results. If the analysis is based on data previously collected, and it is not possible to introduce additional reliability checks, perhaps the title of the study should be changed to "Reported Causes and Characteristics of Single-Car Accidents."

Regarding the author's new "cause system," I feel that he should be commended for his efforts along these lines. Committees have struggled with this problem for a long time, but they have been hampered in their efforts by a requirement that such a system have majority acceptance. This has ruled out experimentation, and has kept any agreed upon system simple to the point of being almost useless as far as accident analysis is concrened.

But the author's cause classification system raises questions about the techniques employed to insure proper classification of the accident circumstances. For example, he comments that data on speed, prior to impact, are derived from participants' and witnesses' statements, and from estimates by investigating officers, and that the data "are necessarily of a low order of reliability." But he then lists speed as one of the cause items, and includes analyses of it throughout the entire report, without any further evidence of the reliability of this statistic.

The same concern exists regarding the definition of the other cause factors. For example, how is drowsiness determined? Were doctors consulted regarding the medical problems category? Was HBD data taken from reports on accident forms (long suspected of being unreliable), or was it determined from autopsies, blood, breath, or behavioral tests? The literature suspects that because of the stringent requirements for evidence in court, when in doubt about the involvement of alcohol, investigating officers will avoid assigning accidents to this category. The drug item may be equally questionable; and wouldn't it be desirable to separate HBD and drugs?

Faulty driving would seem to contain the ingredients for wide variations in the actions to be included, and for possible nonuniformity in the data. What does the category contain, and how was it determined? Was mechanical failure determined by a mechanic? What was the basis for determining that vehicle design was faulty, and who made this diagnosis?

Distraction inside and outside the vehicle should contribute to a better understanding of accident causes, but this item, as well as some of the other items in the new cause system are not generally included on routine accident reports. Were special supplementary investigations made to get this information?

Even more important than questions about the definition and source of the cause items is the basis for assigning a single cause to each accident. In view of multiple causation of most accidents, and general agreement that several factors must co-exist to produce an accident, why was only one cause selected to describe each accident? And what criteria were used for selection?

Admitting a possible advantage for analysis purposes of describing each accident with a single cause, there must be many where more than one cause could as easily have been selected. For example, if a driver was distracted while speeding, and ran off the road, what would be the criteria for selecting one or the other as the single cause? Neither one of these causes by itself may have produced the accident; each may be equally important.

On sex of driver, the author quite properly attempts to equalize the exposure of male and female drivers, introducing travel data from an earlier department study. The technique is generally satisfactory, but conclusions should be handled cautiously since quantitatively equal exposure is not necessarily quantitatively equal. A study by National Family Opinion showed that while males did 73 percent of all driving, their proportion increased to 76 percent in rural areas where the mileage death rate in 1961 was 6.9, and their proportion was down to 69 percent in urban areas where the death rate was only 3.1. The male proportion of driving is also higher after dark when the mileage death rate is three times higher than during the day. In rural areas at night, when death rates are the highest, 80 percent of the driving is done by males, according to this survey.

It is possible that if the quality of exposure could be equalized as well as the quantity of exposure, women may not prove to be better drivers than men. They may even prove to be poorer drivers than men, a fact that could influence the approach to this phase of the problem.

In the factor analysis, since drinking, speed, and faulty driving all represent law violations, use of the general term "rashness" seems quite mild. Possibly a term such as "irresponsible driving" might be more descriptive.

And, since there is reason to suspect that males and females drive differently, drive in different environments, and have different accident experiences, it seems possible that combining them into a single factor analysis might fail to reveal significant differences in the management of the motor vehicle by each sex.

The motor vehicle accident problem is a highly complex one that I feel will not be corrected with a generalized approach. Every opportunity should be used to reveal contributing cause data in as detailed and specific form as possible, again keeping in mind that the principal purpose for studies such as this one should be to identify information which can be useful in preventing accidents.

Unfortunately, studies such as this one, which have great potential for revealing new and useful information on motor vehicle accidents, often must be done with data already in existence, or under other handicaps arising out of data deficiencies. The comments in this report on the study are not intended to be critical of the study itself, which in general is excellently done, but rather are made with the fervent hope of offering encouragement for upgrading the quality of source information.

C. F. McCORMACK, U. S. Bureau of Public Roads.—I sympathize with Mr. Penn. He has encountered the continuing difficulties of accident cause investigators attempting to utilize data and opinions provided by routine accident reports of police officers not fully trained in accident investigation.

Deficiencies in basic data describing circumstances surrounding, actions during, and participants in the accidents surveyed have lead the researcher into some rather questionable observations. (I prefer not to call them conclusions.)

According to the 1961 Inventory of Traffic Safety Activities, California had a reporting ratio of 42 nonfatal accidents to each fatal accident. The true reporting ratio is probably more than three times this much according to an analysis of accident reporting in HRB Bulletin 158. The 1961 ratio ignores as inconsequential, accidents resulting in low property damage even though such accidents may be of significance in discussing contributing causes of accidents, particularly those during inclement weather. Thus, the sample can be said to be too small although the number of accidents studied is twice what statistical analysis required.

The analyses discussed are predicated on conclusions reported by traffic officers who investigated the accidents and interpretations of causative circumstances by personnel of the central office who set up the data for analysis. Both are judgment procedures and both can lead to erroneous results because of the unreliability of judgment decisions made by a large number of individuals. This is particularly noticeable in observations as to speed and faulty driving. Both of these terms, if defined at all,

must be loosely defined and, therefore, subject to wide variation in their assignment as actions contributing to accidents.

Several observations are at variance with what has been accepted in the past. While these variances do not make present observations wrong, they certainly require more documentation than the data upon which they are based will permit. As an example, the report stressed the purported fact that solo crashes are more severe than multiple-car crashes. While not attributable directly to the author, the implication that coffee breaks are likely to reduce driving efficiency, certainly is at variance with the "frequent-stop" policy safety promoters have been urging on motorists.

Not all observations are based on the source data available to the study. What, for instance, leads to the observation that male drivers are unsafe because they have aggressive tendencies while female drivers lack manipulative skill? Are all distractions within the vehicle attributable to other occupants of the vehicles? Should not there be consideration of such actions as lighting cigarettes, tuning radios and fumbling in glove compartments? It would appear that the author may be jumping-the-gun on the second and third parts of his research.

Relating sex of drivers to miles driven is an advance over most studies of this type. However, simple miles driven are not a complete measure of exposure. A more accurate measure would be miles driven related to daylight and darkness, bad weather, and highway and traffic conditions.

Perhaps some of these difficulties will be overcome in the next two parts of the study dealing with biographical data and attitudes of drivers.

I hope these comments do not discourage Mr. Penn—rather, I hope, they will encourage him. In fact, Mr. Penn is in a unique position. Gathering together into one highway transportation agency, as they have in California, the department of highway patrol, the department of motor vehicles, and the division of highways should permit more thorough examination of all conditions and circumstances involved in motor vehicle accidents. Specifically, data on driver characteristics and highway and traffic conditions should be more readily available to him in the continued examination of highway accidents.

HUGH S. PENN, Closure.—There were obviously too many points raised by the panel to discuss each specifically. However, to cover some of the more telling criticisms, I might discuss two of the topics raised by Mr. Baker. One concerns tests of the temporal distribution of some of the variables studied. While the work was being done, tests of randomness were made of the variables, but because the report was originally intended for local consumption, a statement regarding this phase of the investigation was not included. It can be made part of any future versions of the study.

Mr. Baker's remarks about single-car accidents possibly being a function of highway improvements is quite apropos. It is quite conceivable that when drivers cannot find cross traffic to run into, they will collide with guardrails, bridge abutments and the like.

In general, the criticisms of the panel covered three general areas: the limitations of the accident report as a source of information, the reliability of this study, and the nonuse of population values in evaluating some of the findings of the study.

I have worked with accident reports for many years, and I agree wholeheartedly with criticisms of them as a source of data. But what is the alternative? Virtually the only other means of obtaining accident information are costly, time-consuming, on-the-scene investigations. Few agencies are equipped or funded to make such investigations. At present, virtually all approaches to the traffic problem utilize the accident report in one way or another.

On the score of reliability, I would like to observe that I, and other persons who have looked into the subject, know that policemen tend to report events in stereotypes. This should not be interpreted as meaning that guardians of the law are not capable of

independent thought but that the list of approved motives of public conduct is rigidly defined, and many of the categories become catch-alls.

This study was based on an attempt to get behind these stereotypes and to see whether a more revealing view of accident causation might not result from using a fresh cause schedule.

The work was done as carefully as possible. Those supervising the coders were given written instructions, training sessions were held, and difficult decisions were brought to me for determination. As is the case in any endeavor using people, all with varying backgrounds and capabilities, it is certain that there will be minor inconsistencies. However, this is true of the more conventional accident statistics: they are derived mainly from the accident report; they are coded, tabulated, and summarized; and then are received as authoritative.

In regard to the use of population values to evaluate research findings, I assure you that I would be most happy to use them if they were available. Many of the statistics presently compiled seem to have little or no relation to accident causes. For example, in California, we compile every year the number of drivers in accidents who have valid licenses. But if one looks for, say, the annual mileage of 17-year old boys, or the number of vehicular occupants exposed to death or injury in crashes, or even the number of women in the driving population, he will look in vain.

I should like to thank the members of the panel for their thoughtful review of this part of the study. However, I feel that many of the weak points they have pointed out are due to deficiencies in the material available for making such studies.