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Making Accident Statistics More Meaningful*

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INTRODUCTION

With the improvement in driver licensing and highway policing systems throughout the country there has arisen the need for better reporting and analysis of accidents and accident trends. Many states have inaugurated standard IBM equipment and follow a more or less uniform system of recording and punching accident data on cards for machine analysis. In most respects the trends in this development have been very desirable but standardization is sometimes a virtue which may occasionally boomerang. After a system is once established it takes a great deal of effort to make a change and changes are frequently desirable. Standardization may thus become a hindrance to progress. In other areas this may be readily illustrated by the English and American system of mensuration as well as by our clumsy 12-month calendar.

However, the purpose of this paper is not to propose a new system, but to add some needed extensions and improvements which make any system now in common usage much more effective. An illustration using actual data will be set forth to illustrate one type of problem in the field of accident prevention.

THE PROBLEM

Altho most licensing departments are reasonably well equipped with newer devices such as card systems, computing machines, microfilming apparatus, etc. they are usually understaffed. This means that the material collected on accidents, violations and otherwise, cannot be analyzed to the best advantage.

Every motor vehicle department should be properly manned by two distinct types of personnel. By far the larger portion should be qualified clerically and legally trained persons who will handle the bulk of the routine type of matters of the department. In addition there should be a small research section manned by technical personnel. A well-trained combined statistician and psychologist with executive ability, serving as director, should spearhead this group.

*The constants and indices used in this study were made available by a research on *The structure and characteristics of the driving population—Part I—Iowa* made in the Driving Laboratory, Industrial Science Research Institute, Iowa State College in cooperation with the Department of Public Safety in Iowa through a grant from the Allstate Insurance Company.

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This combination is commonly found in research departments in business and industry as well as in schools and colleges. The psychologist is more likely to be well grounded in statistics and scientific methodology and also, if properly selected, knows enough about psychiatric problems to call in help on a consulting basis if needed. Also being out of the fold of "legally protected" professions he may be procured at a figure not out of line with the usual salary schedules paid state employees of comparable rank and training.

With such a research staff the data collected could be rendered much more meaningful as will be illustrated in the following section. Recently we released figures which showed certain facts as gleaned from the conventional type of analysis of accident records available in the State of Iowa. These were carefully tabulated and compiled and were accurate as well as reliable so far as the analysis was carried out. In a liason research study with the Driving Laboratory at Iowa State College a very comprehensive analysis of accident files in Iowa through an adequate sampling technique, had given certain constants and correction data which are not immediately available in the State files. The most important of the values needed for present illustrative purposes was the number of drivers of each sex in the files as of the present, (this may change from year to year) the number of each single age group from 14 on through to 99 years of age as well as data on mileage driven by each age group. It has been customary to group accident data into course groupings which preclude critical analysis by ages. By having the data broken down by years it is possible to recombine them into as many types of groups as desired. At present the State system* of grouping is set up differently but the research data collected by the Driving Laboratory is recorded by years and it is possible in a few hours time to regroup the results to fit the state system with nothing more than ordinary clerical work under qualified research supervision. No recalculations are necessary. Many other types of crucial data could be worked out by a regular resident-staff of research workers.

Needed Refinements

In general the present system of accident reporting needs at least two additional features to make the reports much more meaningful, viz.:

1. Certain correction constants and indices on numbers in the groups used, age characteristics, driving mileage by year, gasoline consumed, cars registered and the number of licensed driv-

*It should be stated that the reporting system in Iowa does break groups down further than the example given but does not make a regular yearly breakdown.

ers by age as well as the driving risk involved, time of day in which driving is done, etc. Certain of these are almost a *must* for meaningful reporting. One need only mention the old adage about "white sheep eating more than black ones—because there are more of them."

2. Rather definite statistical evaluation indices which are in common usage and which give a basis for determining the significance of changes in one direction or another. It is a well known fact that successive observations of any phenomenon will vary from time to time according to the laws of chance. Many such changes are meaningless and even the more extreme variations will not be accepted by scientifically-minded individuals unless they are accompanied by indices showing the confidence level established or the degree of certainty which may be assigned to them by standard methods of evaluation.

Both of these refinements only require a well trained research worker and the cost of one or two full-time assistants to work miracles in any motor vehicle department. It is barely possible that much of what is ordinarily collected is useless anyway and a careful revision of the system might eventually cost less than the system now in use, yet give more useful results. Such technical positions should be Civil Service or other permanent tenure basis and not subject to political appointment.

An Illustrative Case

The release cited made comparisons between the ages of drivers involved in fatal accidents during the first nine months of 1949 and 1950 respectively. It was shown that there were 465 motor vehicle deaths during this period in 1949 and 491 fatalities in 1950 for the same nine-month period. We do not have available data to show the comparisons of mileage traveled in Iowa for this period in the two years, the number of cars registered or the number of licensed drivers registered. A further breakdown shows 26 deaths, or a net increase of 5.39 per cent without correction for certain other factors, and may or may not indicate an actual proportional increase. With the assumption that such variables as the number of licensees, mileage driven and the number of cars registered remained constant during the two years—altho there must have been some increase—we may proceed to test the significance of the increase. Under the assumption that the mean of the two would be a more nearly accurate figure we may set up such hypothesis and test it by the X^2 technique which is a simple type of formula stated as follows:

$$X^2 = \frac{(f_o - f_t)^2}{f_t}$$

where f_o = the frequency of the observed values, f_t is the expected or theoretical frequency. Certain more imposing formulas are actually easier to use but we need not be concerned with those here. Thus the test runs as follows:

Table I

Comparisons of Fatal Accident Data for Statistical Significance.

1949		1950		
Actual	Expected*	Actual	Expected*	
465	478	491	478	Total = 956

$$= \frac{(465 - 478)^2}{478} + \frac{(491 - 478)^2}{478} = \frac{169}{478} + \frac{169}{478} = .353 + .353 = 70.6$$

critical review of methodoilogy. *Psychol. Rev.*, 1942,*49*, DFC-DGD.

From most any modern text on statistical methods it will be found that the probability of a difference existing according to the hypothesis set up with this number of degrees of freedom** is about 45 chances in 100 or not quite 50-50. Therefore if any consideration at all is given mileage and similar factors there is not much reason to think that the increase in any statistical sense is significant.

If we proceed to study the groups we find the following results may be further analyzed for meaningfulness by ordinary methods:

Table II

Fatal Accidents—Uncorrected Data as Released.

Driver Age Group	Deaths 1949	Deaths 1950	Change
Under 20	58	80	38.00% increase
21-24	73	68	7.00% decrease
25-64	300	304	1.33% increase
65 & over	34	39	15.00% increase

Now from the figures alone we are able to note a change which looks significant for the "teen-age" group but we have no assurance that the increase is reliable. Therefore, we may proceed to analyze this by the technique described without going to the trouble to go back and calculate additional statistics or values. From our liason research study we have found two sets of values or indices which make the picture considerably clearer. One has to do the number

*On the basis of the hypothesis set up.
**One less than the number of groups in the present case.

of drivers in each age group and the other has to do with the total mileage driven by each group. By inserting these the picture is somewhat changed.

Table III

Evaluation of Fatal Accident Drivers on the Basis of Number of Drivers.

Driver Age Group	Percent of Drivers in Group	Deaths — 1949		Deaths — 1950	
		Number	% Attributable Deaths	Number	% Attributable Deaths
20 & below	10.62	58	12.50	80	16.32
21-24	9.22	73	15.71	68	13.85
25-64	72.70	300	64.60	304	62.20
65 & over	7.63	34	7.32	39	7.97
Totals	100.19	465	100.13	491	100.34

Here we see that on a percentage basis there is considerable difference in the various groups and it would be possible to calculate various indices or ratios if desirable. For example, drivers below 20 had 17.7 per cent more fatalities than their share in 1949 and 53.4 per cent more than their share in 1950, and so on with the other groups. By a similar comparison the 21-24 year group had 70.4 per cent more than their share of accidents in 1949 and 50.2 more than their share in 1950. Thus on an actuarial basis the average excess for the 20 and below group averaged 35.5 for the "teen-agers" and 60.3 for the 21-24 year group.

Likewise, in the research study mileage constants were calculated for each age level and the data can readily be combined into another form of table according to the mileage traveled by each age group.

Table IV

Evaluation of Fatal Accident Drivers on the Basis of Mileage Driven.

Driver Age Group	Percent of Miles	Deaths — 1949		Deaths — 1950	
		Number	% Attributable Deaths	Number	% Attributable Deaths
Under 20	7.77	58	12.50	80	16.32
21-24	10.46	73	15.71	68	13.85
25-64	76.20	300	64.60	304	62.20
65 & over	5.76	34	7.32	39	7.97
Totals	100.19	465	100.13	491	100.34

Thus on the basis of mileage we have another picture. The fatal-accident drivers below twenty had 60.9 per cent more than their share

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of accidents according to mileage in 1949 and 110.00 per cent more than their share for 1950. Hence the percentage increase seems even worse than when calculated from the uncorrected data. A similar comparison of the 21-24 group showed they had 50.2 per cent more than their share of fatal accidents on a mileage basis in 1949 and 32.4 per cent more in 1950. From the actuarial and public safety point of view our 21-24 year group is the greatest menace but, considered on a per-mile basis, the "teen-age" group has the poorest record. It should be noted that had the 20-year-old group not been included with "teen-agers" the results would change somewhat. Some rather loose classification of data have been made in numerous periodicals during the past three years.

Going back to the percentage of drivers in each group we may also make other crucial comparisons. There are about 1,300,000 drivers in Iowa. This would mean there are some 138,000 drivers 20 and under in Iowa. Assuming there was one youthful driver in every fatality attributed to this group there would be 1 fatal-accident driver to about every 24,000 drivers of all ages or about 1 in 2,300 of their own age group. For the 21-24 year group there would be about 120,000 drivers and about 1 fatality for every 1,650 drivers in their own age group. These calculations were for 1949 during the nine-month period indicated. In 1950 the figures would seem to be reversed for the 21-24 year group, with those 20 and below having more fatalities. Again it should be noted that those 20 years old are included with "teen-agers" in Iowa records.

Many calculations of this nature may be made to spot the trends and indicate the degree of emphasis and improvement which should be made in the enforcement program. We have only cited typical analyses which may be extended on as desired. It is interesting to observe that since about half the population hold licenses this would indicate that relatively small groups of young drivers are doing most of the damage within their respective age groups and the entire younger group should not be stereotyped as "killers." It suggests the need for greater care in training and licensing drivers with greater restrictions being placed on the younger groups during the first years of licensure. The sampling of Iowa drivers studied showed a deficiency in reported accidents among the "teen-agers" which also further lends support to the argument that only a few "bad actors" are having the serious accidents. The remedy would seem to be that of ferreting out the potential hazards before harm is done. Also it may imply the need for a junior license from 16 to 21 with lower speed limits on the secondary roads.

Crucial Evaluation Procedures

There is still another step which may be taken to make accident data more meaningful and that is to determine the significance and stability of the differences noted. Are they likely to change the next year as was noted by comparing those below 20 and the age group 21-24 on the basis of numbers in the fatal-accident drivers studied for 1949 and 1950? This is the most important step and is frequently omitted. In fact it is practically never used in most of the accident statistics available. There is no way for the reader to judge the importance of any given results reported unless some evaluation procedure is carried out.

We will now proceed with the same example under the null hypothesis which would be stated as follows: There are no significant differences between the several groups of fatal-accident drivers studied.

An evaluation procedure is set up for estimating the significance of difference found between the two years for each of the two conditions given, i.e., (1) comparison between number of drivers in the group and (2) on the mileage driven for each of the years. These results are shown in Tables V, VI, VII and VIII respectively.

The particular application of the results obtained depends upon what one wishes to know. The example merely illustrates some of the possibilities which may be explored in accident-record analysis carried out on a scientific basis. It should be clearly emphasized that this is in no sense a "juggling" of statistics for a purpose. It is a straight-forward presentation of reasons why complete analyses should be made of records in order to preclude "juggling" or partial presentation which frequently obscures the picture and leads to misunderstanding.

Table V

Apportionment of Fatal Accidents on a Driver Basis—1949.

Driver Age Group	Per cent of Drivers	Deaths Actual	Deaths Expected	$f_o - f_t$	$(f_o - f_t)^2$	X^2
20 & under	10.62	58	49.48	+8.52	72.59	1.467
21-24	922	73	42.80	+30.20	912.04	21.309
25-64	72.70	300	338.00	–38.00	1444.00	4.272*
65 and over	7.63	34	35.40	–1.40	1.96	0.055
Totals	100.17	465	465		Sum X^2 = 27.103	
					P = less than .01	

*The differences here are also slightly significant with three degrees of freedom. All data recorded from Jan. 1 to Sept. 30, the year indicated. From the components of the total chi square it would seem the excess for the 21-24 year-old group is quite significant.

Table VI

Apportionment of Fatal Accidents on a Driver Basis—1950.

Driver Age Group	Per cent of Drivers	Deaths Actual	Deaths Expected	$f_o - f_t$	$(f_o - f_t)^2$	X^2
20 & under	10.62	80	52.14	+27.86	776.18	14.886
21-24	9.22	68	45.27	+22.73	516.18	11.413
25-64	72.70	304	356.96	–52.96	2804.76	7.857
65 & over	7.63	39	37.46	+1.54	2.37	.063
Totals	100.17	491	491.83		Sum $X^2 = 34.219$	
					$P =$ less than .01	

*The differences here are also slightly significant with three degrees of free-same number of degrees of freedom as in Table V. It would be stated that the groups do not have accidents according to the number in the group and the evidence is strongly against the first two groups.

Table VII

Apportionment of Fatal Accidents on a Mileage Basis—1949.

Driver Age Group	Per cent of Miles	Deaths Actual	Deaths Expected	$f_o - f_t$	$(f_o - f_t)^2$	X^2
20 & under	7.77	58	36.05	+21.95	481.80	13.365
21-24	10.46	73	48.61	+24.39	594.87	12.238
25-64	76.20	300	354.00	–54.00	2916.00	8.237
65 & over	5.76	34	26.80	+7.20	51.84	1.934
Totals	100.19	465	465		Sum $X^2 = 35.774$	
					$P =$ less than .01	

Here the differences are far below the .01 per cent level of confidence and the group are markedly different from the average of all except of those 65 and over.

Table VIII

Apportionment of Fatal Accidents on a Mileage Basis—1950.

Driver Age Group	Per cent of Miles	Deaths Actual	Deaths Expected	$f_o - f_t$	$(f_o - f_t)^2$	X^2
20 & under	7.77	80	38.30	+41.70	1738.89	45.402
21-24	10.46	68	51.40	+16.60	275.56	5.361
25-64	76.20	304	374.00	–70.00	4900.00	13.102
65 & over	5.76	39	28.20	+10.80	116.64	4.136
Totals	100.19	491	491.90		Sum $X^2 = 68.001$	
					$P =$ less than .01	

Again the differences are very highly significant as given in standard tables. The 20 & under group have a higher fatality record.

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While it is not ordinarily considered sound to apply components of the total chi-square, separately, as a test of significance; it is axiomatic that the components found in the younger age groups constitute the major contribution to the total. Methods are available for testing combined group differences in order to isolate the separate group significance but such procedures will not be discussed here.

Also, in Table I it should be stated that this example is merely illustrative. The hypothetical values from which base the expected values are calculated would be much more accurate when based upon several years average. In that case both years might be compared at the same time to indicate trends and the significance of trends.

Summary and Conclusions

It is pointed out that motor vehicle enforcement, licensing and accident statistical department personnel should be of two general types, one large group of clerically and legally trained workers and a smaller highly trained research group. The latter should function under the direction of a well-trained man, preferably an experimental psychologist who also has more than an average amount of statistical training and experience. With such a combination the real value of accident statistics would emerge for use in strategic educational, enforcement, legislative and administrative policies.

A typical example of accident reporting is used to illustrate the application of well known statistical evaluation techniques which are rarely used in accident statistics. It is shown that much more meaningful results can be obtained if the proper correction constants are available and applied. These constants and indices should be derived to fit the time, the driving conditions and the other exigencies of the department and locale.

It is indicated that the elimination of much unnecessary routine might well save enough time and money to provide for the inauguration of scientific personnel necessary to make the more complicated analyses which would reveal many facts obscured in raw accident statistics. The same personnel would be admirably trained to function in a remedial way with various types of offenders.

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