BLOOD ALCOHOL TEST RESULTS OF MOTOR VEHICLE DEATHS AS AN EVALUATION METHOD FOR THE FAIRFAX ALCOHOL SAFETY ACTION PROJECT

by

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A Report Prepared by the Virginia Highway Research Council Under the Sponsorship of the Highway Safety Division of Virginia

"Prepared for the Department of Transportation, National Highway Traffic Safety Administration, Under the Contract No. DOT-HS-067-1-087. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration."

Charlottesville, Virginia

April 1973

Final Report

VHRC 72-R33

ABSTRACT

The Fairfax Alcohol Safety Action Project (ASAP) was started following the June 1971 approval of the proposal and working plan submitted to the Department of Transportation by the Highway Safety Division of Virginia. A total of $2,123,000 was allocated to the Safety Division. Of the five alcohol countermeasures that constitute the ASAP, one is administration and evaluation. As a part of the evaluation countermeasure, it was decided to determine if the Virginia State Medical Examiner's blood alcohol concentration (BAC) tests of fatally injured motorists could be used in evaluating the project's effectiveness.

Three analytical techniques using the BAC test results were defined and evaluated: (a) Difference between mean positive BAC's, (b) expected total (positive and negative) BAC mean and corresponding confidence interval, and (c) significance of a shift in the total BAC distribution. The findings resulting from use of these techniques permitted several conclusions. By employing the techniques, the BAC test results can be useful in evaluating the ASAP project, although the relatively small Fairfax sample requires a sizeable shift in the data before it can be statistically shown that ASAP is having an impact. Further, once ASAP is implemented on a statewide basis, the analytical techniques used here will be much more powerful in detecting its impact.

Appendix A is a preliminary evaluation of the alcohol tests on 1972 Fairfax motor vehicle fatalities.

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INTRODUCTION AND PURPOSE

In June 1971, the proposal and working plan for the Fairfax Alcohol Safety Action Project (ASAP) submitted to the Department of Transportation by the Highway Safety Division of Virginia was approved, and $2,123,000 was allocated to the Safety Division to implement the project. The ASAP is designed to demonstrate the relationship between alcohol and highway crashes and to implement the community alcohol countermeasures concept. The five countermeasures constituting the Fairfax ASAP are police enforcement, judicial, rehabilitation, public information and education, and administration and evaluation.

The evaluation countermeasure is designed to provide specific summary information to the National Highway Traffic Safety Administration for use in the evaluation of the ASAP's at the national level. Further, it is designed to evaluate the overall impact of the individual ASAP and of each of its countermeasures, including an evaluation of the cost-effectiveness where possible. It was the purpose of the study reported here to determine if the results of the Virginia State Medical Examiner's blood alcohol concentration (BAC) tests on persons killed in motor vehicle crashes can be effectively used in the evaluation of the Fairfax ASAP.

METHODOLOGY

After determining the nature, size and acceptability of the results of the BAC tests obtained from the Chief Medical Examiner, the study attempted to define and evaluate the following three analytical methods:

(a) Test of significance for the difference between mean positive BAC's using the Student's "t".

(b) Establishment of an expected total BAC mean and a confidence interval around this mean in which a future total BAC mean could be expected to fall.

(c) Test of significance for a shift in the total BAC distribution using the chi-square test.

NATURE, SIZE AND ACCEPTABILITY OF SAMPLE

The results of alcohol tests on persons killed in motor vehicle accidents during the period 1967-1971 in the state of Virginia, Fairfax, and Henrico County[1] / Richmond City were used in the study. The total was broken down into motorcycle, driver, passenger, and pedestrian categories. Further, each category was divided into ten BAC intervals from negative to 0.40% and over. Henrico/Richmond City was selected as a control for Fairfax instead of Henrico County alone. This decision was made because most of the fatalities in Henrico County receive BAC tests in Richmond City facilities and are recorded in the Richmond figures. Also, Henrico County figures of BAC test results represent only a small percentage of the number of motor vehicle deaths in Henrico.

It is the intention of the Chief Medical Examiner of Virginia to perform a BAC test on motor vehicle accident fatalities which occur within four hours after an accident. In all but the most unusual cases this testing is accomplished. Table 1 compares the total of motor vehicle crash victims to the total on which alcohol tests were performed for the state, Fairfax, and Henrico/Richmond areas in 1967-1971. This exhibit shows that consistently tests are performed on over 50% of the fatalities. In the Henrico/Richmond area the percentage is above 100% in three of the five years, which indicates that some accident fatalities from outside the area are tested and reported by the Henrico /Richmond area medical examiners. It is felt that due to the unbiased manner in which such tests are administered and the large percentage of the total fatalities tested, the data received from the medical examiner represent a reasonable sample of the BAC distribution of all persons killed in motor vehicle accidents.

The data for the three areas in the years 1967-1971 were converted into percentages by BAC category to permit year to year comparisons. The majority of the analyses were made using the total numbers of fatalities broken down by BAC, even though in seeking to evaluate the ASAP, the greatest emphasis might be directed at driver deaths. It was decided to work with total figures because the driver categories in Fairfax represented a very small and extremely variable sample, as can be seen in Table 2. The paucity and extreme variability of the driver data precluded any useful statistical analysis. This problem will not be encountered when ASAP is implemented on a statewide basis. However, it was felt that a shift in the BAC distribution caused by the ASAP in Fairfax would be significant in the total deaths with alcohol tests category.

1/ Henrico County, Virginia was selected by evaluators as the control site against which Fairfax County data may be compared. Henrico County provided the best available match to Fairfax within Virginia on the basis of selected social, economic, and traffic data.

Table 1

Total Crash Victims With Alcohol Tests

Total Deaths	1971	1970	1969	1968	1967
State	1,218	1,231	1,304	1,218	1,223
Fairfax	100	63	60	65	64
Henrico & Richmond	54	59	69	66	50
Total Deaths With Alcohol Tests					
State	646	554	646	719	689
Fairfax	71	47	38	37	36
Henrico & Richmond	74	82	64	53	60
Total Deaths with Alcohol Tests as % of Total Deaths					
State	53%	45%	50%	59%	56%
Fairfax	71%	75%	63%	57%	56%
Henrico & Richmond	137%	139%	93%	80%	120%

Table 2

Fairfax Motor Vehicle Driver Deaths With Alcohol Tests
(BAC Intervals Expressed in Percentages)

Year	Total Deaths	Negative	.01-.04	.05-.09	.10-.14	.15-.19	.20-.24	.25-.29	.30-.34	.35-.39	40 & over
1971	37	13	0	11	14	14	11	5	3	5	3
1970	23	12	0	1	3	3	4	0	0	0	0
1969	21	15	0	1	2	0	3	0	0	0	0
1968	20	9	0	1	2	3	4	0	1	0	0
1967	17	2	1	1	5	1	4	1	1	1	0

FINDINGS

Figure 1 shows a cumulative percentage BAC for the state totals, and Figure 2 shows the Fairfax totals. The graphs for the state exhibit an extremely uniform pattern over the five-year period while those for Fairfax show considerable variability, which is probably due to the relatively small size of the Fairfax sample. It should be noted that with ASAP implemented on a statewide basis, a shift in the BAC distribution could probably be measured graphically on Figure 1. If ASAP were having the desired effect, the graph would start at a higher level and accelerate to 100% more rapidly than the graphs for the previous years. However, the variability of the Fairfax totals prohibits the usefulness of a graphic method of analysis unless a dramatic shift in the BAC levels occurs.

In seeking a useful analytical technique to apply to the BAC distributions, it was noted that the positive BAC readings seemed to display a normal curve pattern. If the positive BAC distributions in fact approximate a normal distribution, then standard statistics could be used for analytical purposes. To test this hypothesis, the state, Fairfax and Henrico/Richmond totals were graphed over the range of BAC categories. Also, the mean, median, mode, and standard deviation for each of the positive BAC distributions were calculated. The results are shown in Figures 3 through 7 for state and Fairfax figures, and in Figure 8 through 12 for the Henrico/Richmond figures.

The hypothesis that the positive BAC distributions approximate a normal distribution is verified by the graphs. In examining the state total graphs, shown on Figures 3-7, it can be seen that the mean of the positive BAC's over the five years has a narrow range of .170%-.178%, and the standard deviation has a range of .079%-.085%. In each year, roughly 68% of the data fall within plus or minus one standard deviation, 95% between plus or minus two standard deviations, and 100% between plus or minus three standard deviations. Hence the positive BAC distributions clearly tend to approximate a normal curve. Although the Fairfax totals, also shown in Figures 3-7, and the Henrico/Richmond totals (Figures 8-12), do not exhibit as consistent a normal pattern as the state totals, this is to be expected since the Fairfax and Henrico/Richmond totals represent much smaller samples and thus are subject to a greater degree of variability. Given the evidence displayed in the graphs and the clear results of the much larger state total sample, it can safely be assumed that the Fairfax and Henrico/Richmond positive BAC readings tend to be normally distributed.

Given that positive BAC distributions approximate normal curves, the important statistical parameters are the mean, the standard deviation, and the sample size. With these parameters, the difference between two sample means can be tested to determine if the two samples are drawn from the same population. It was decided to test the Fairfax sample in each year against the Henrico/Richmond sample in the same year. If it was found that the Fairfax and Henrico/Richmond samples were drawn from the same population for the years 1967-1971, then the test could be continued in the future years of the ASAP to determine if a shift in the BAC distribution in Fairfax had occurred which would change the conclusion that the two samples were from the same population. It was decided to test the Fairfax sample mean each year with the Henrico/Richmond sample mean rather than test the change in Fairfax sample means from year to year.

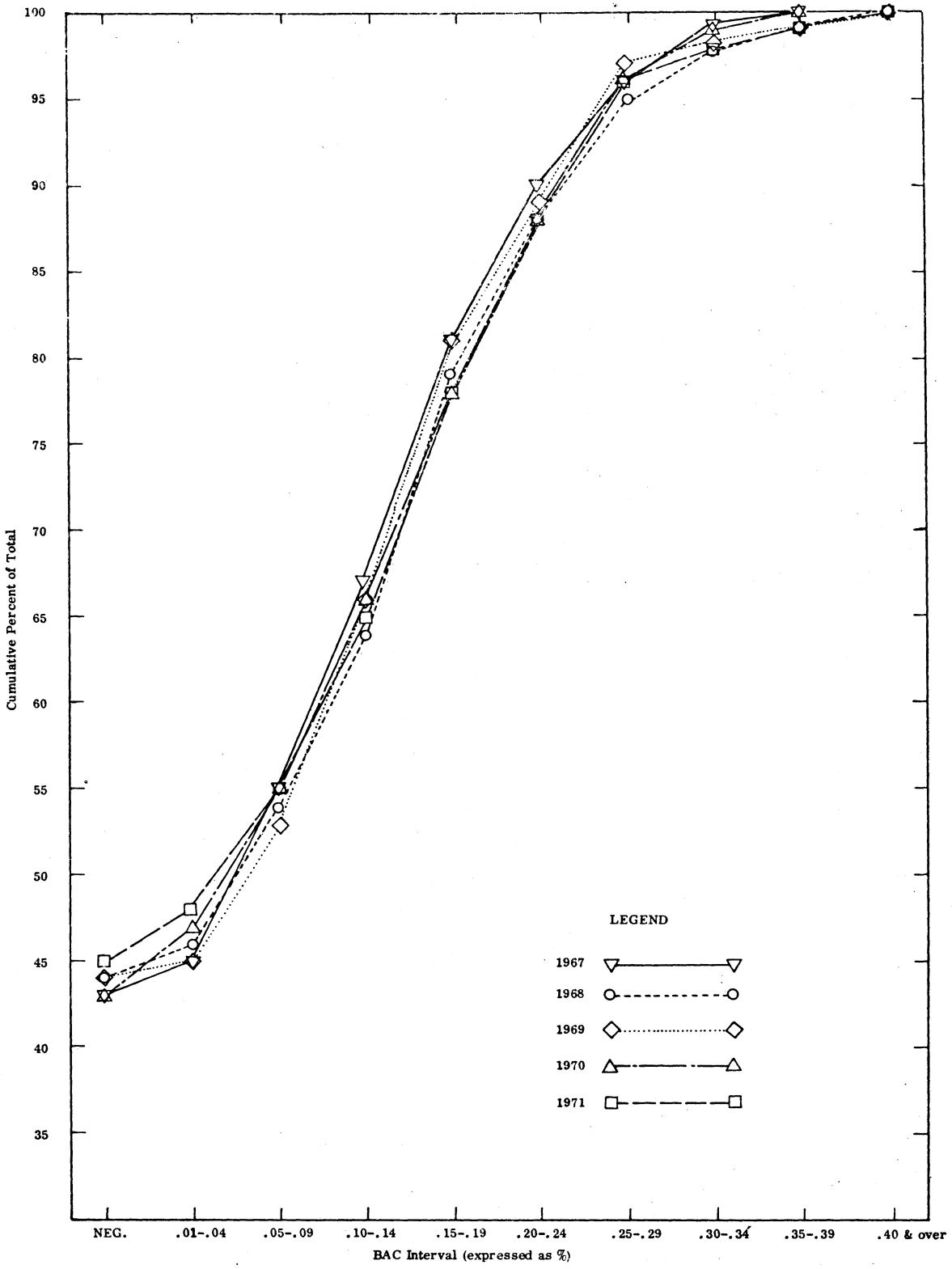

Figure 1. Cumulative percentage BAC — State totals.

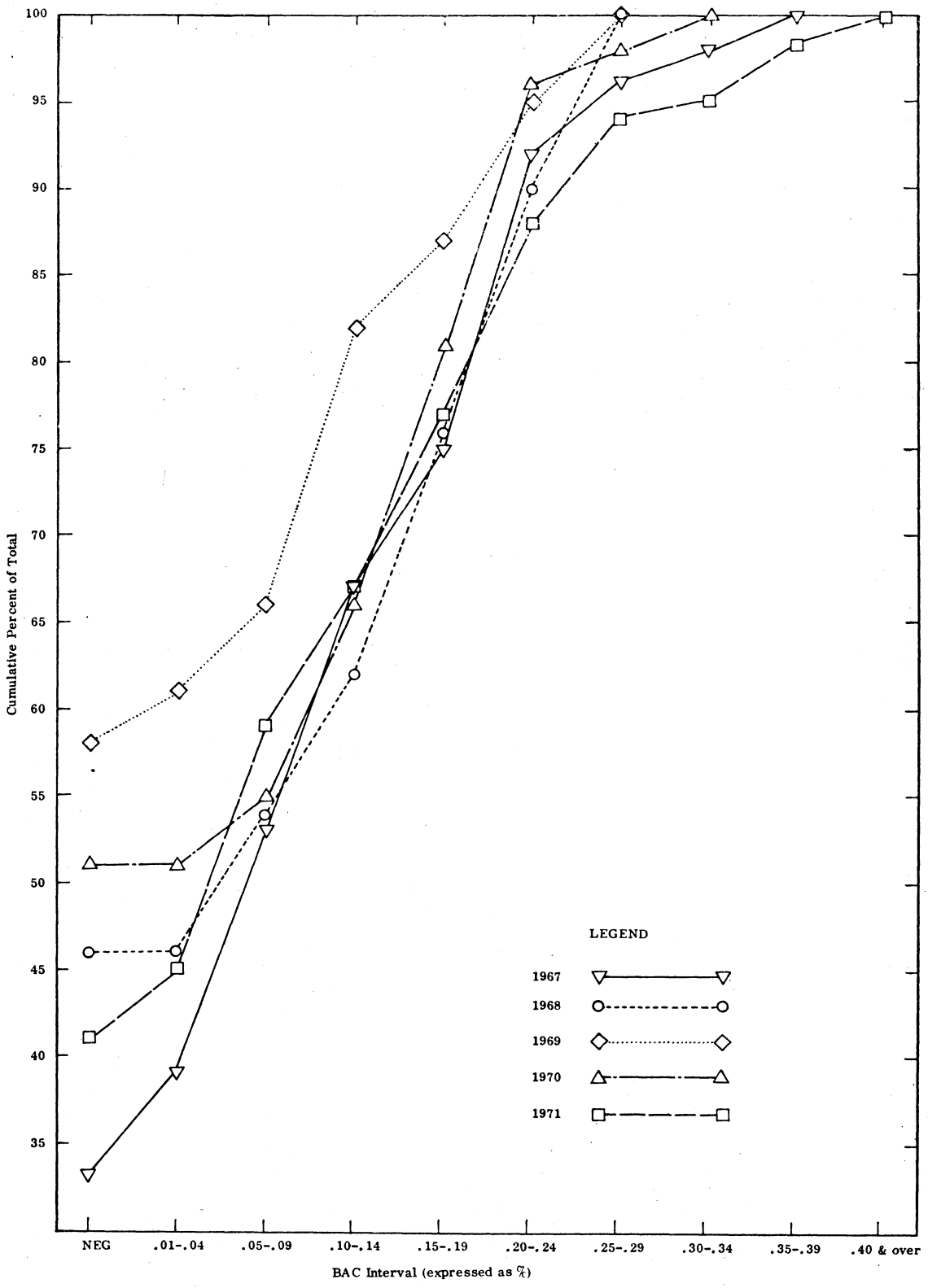

Figure 2. Cumulative percentage BAC — Fairfax totals.

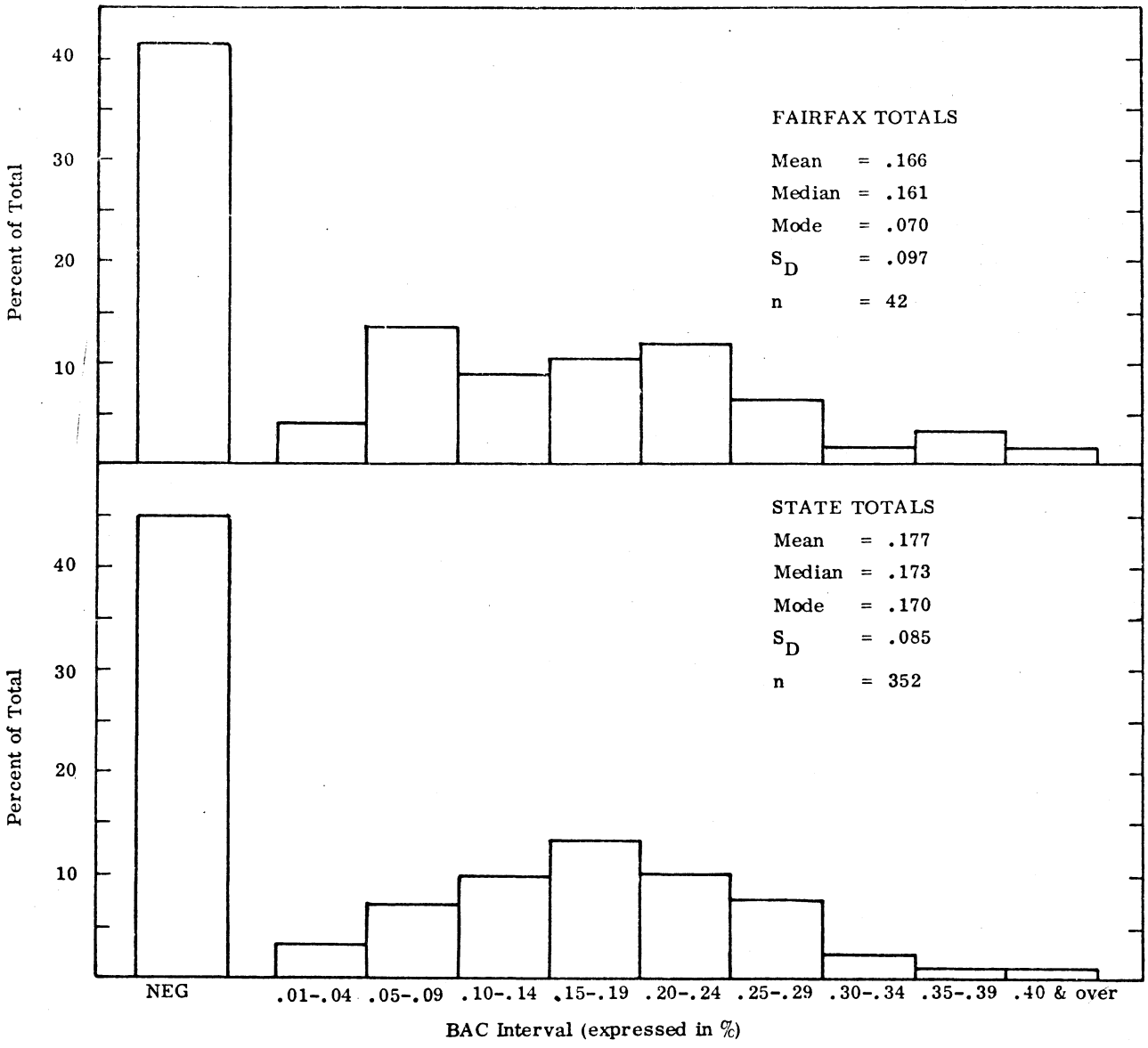

Figure 3. Motor vehicle deaths with alcohol tests, 1971.

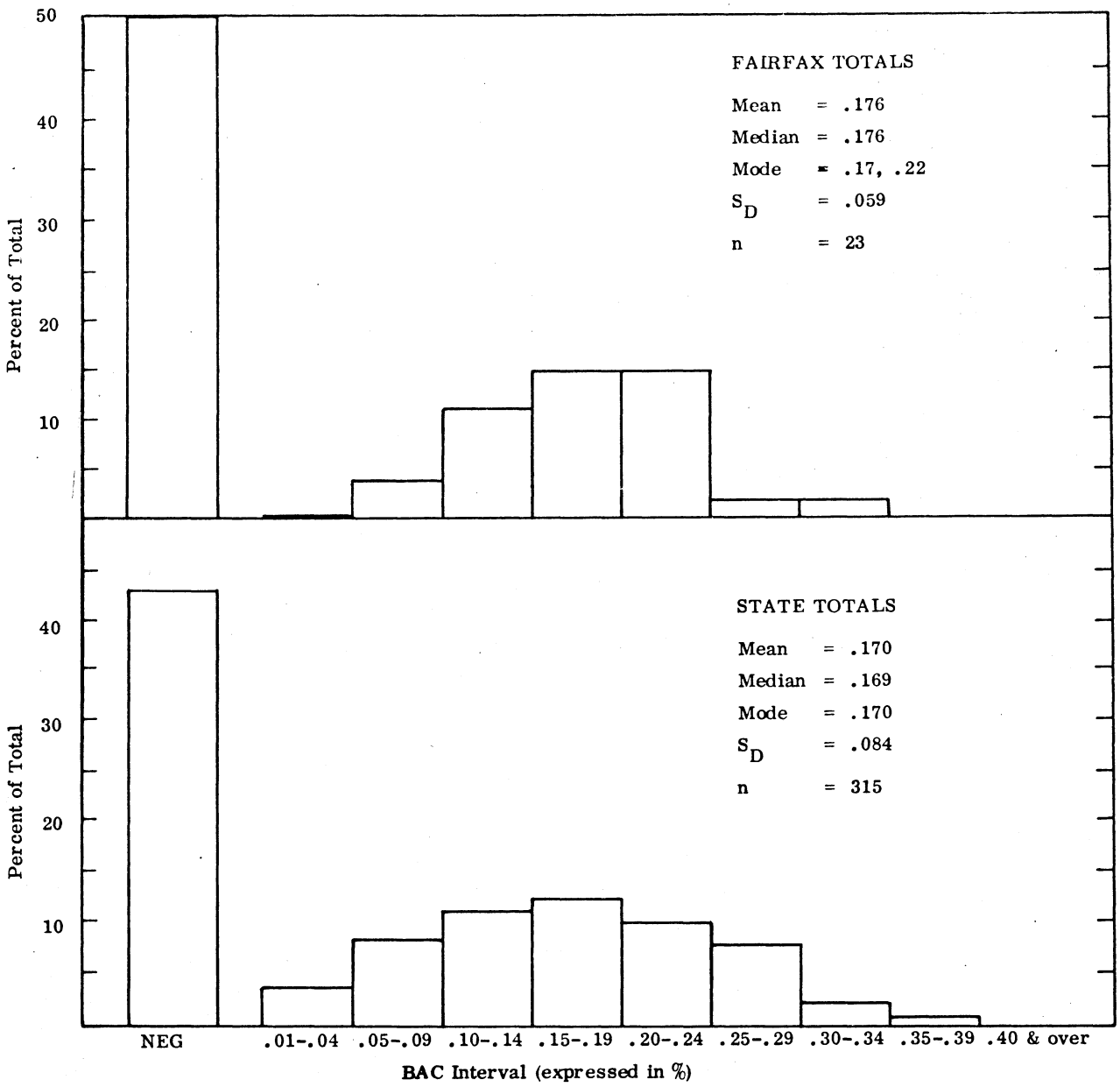

Figure 4. Motor vehicle deaths with alcohol tests, 1970.

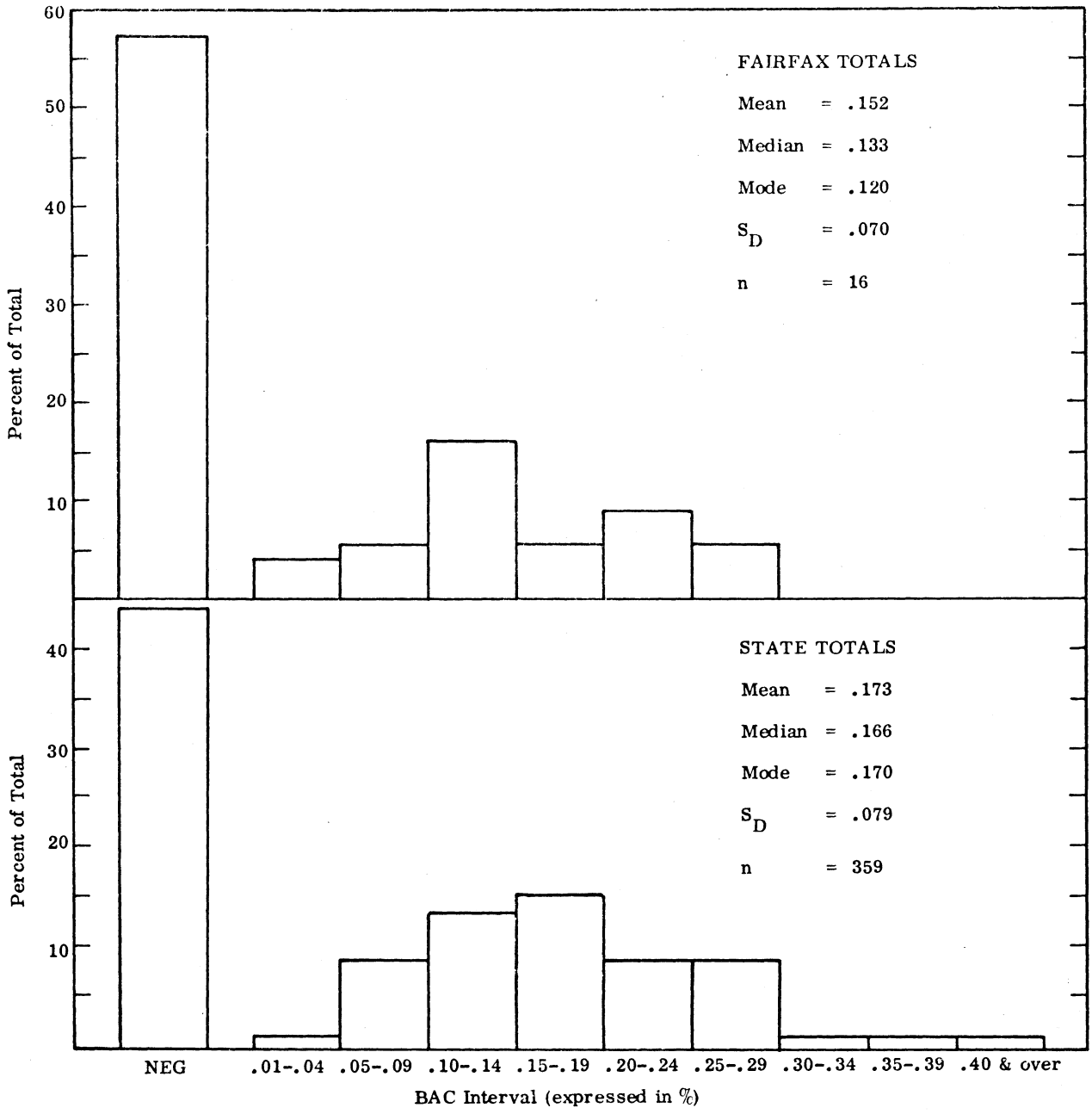

Figure 5. Motor vehicle deaths with alcohol tests, 1969.

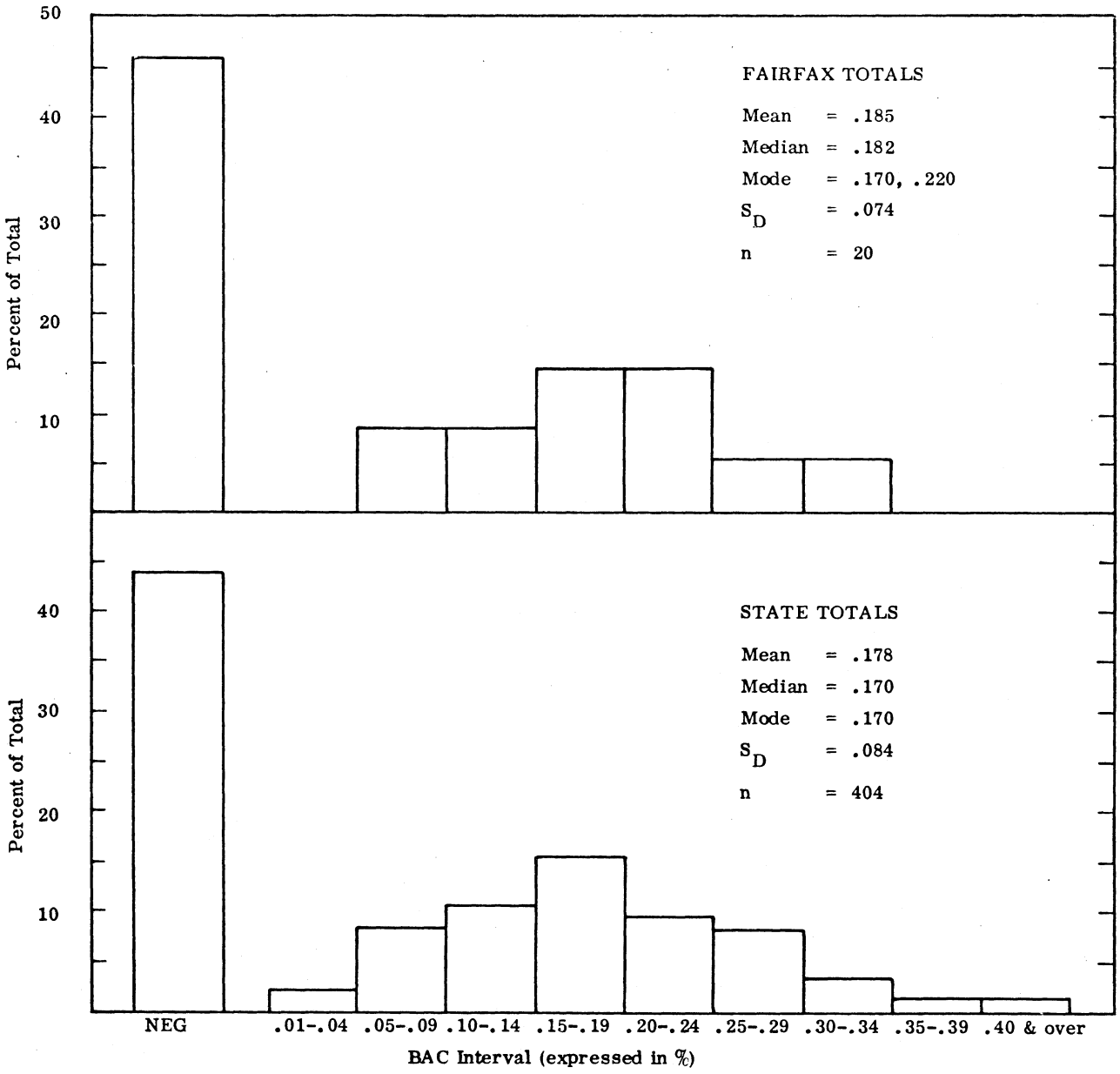

Figure 6. Motor vehicle deaths with alcohol tests, 1968.

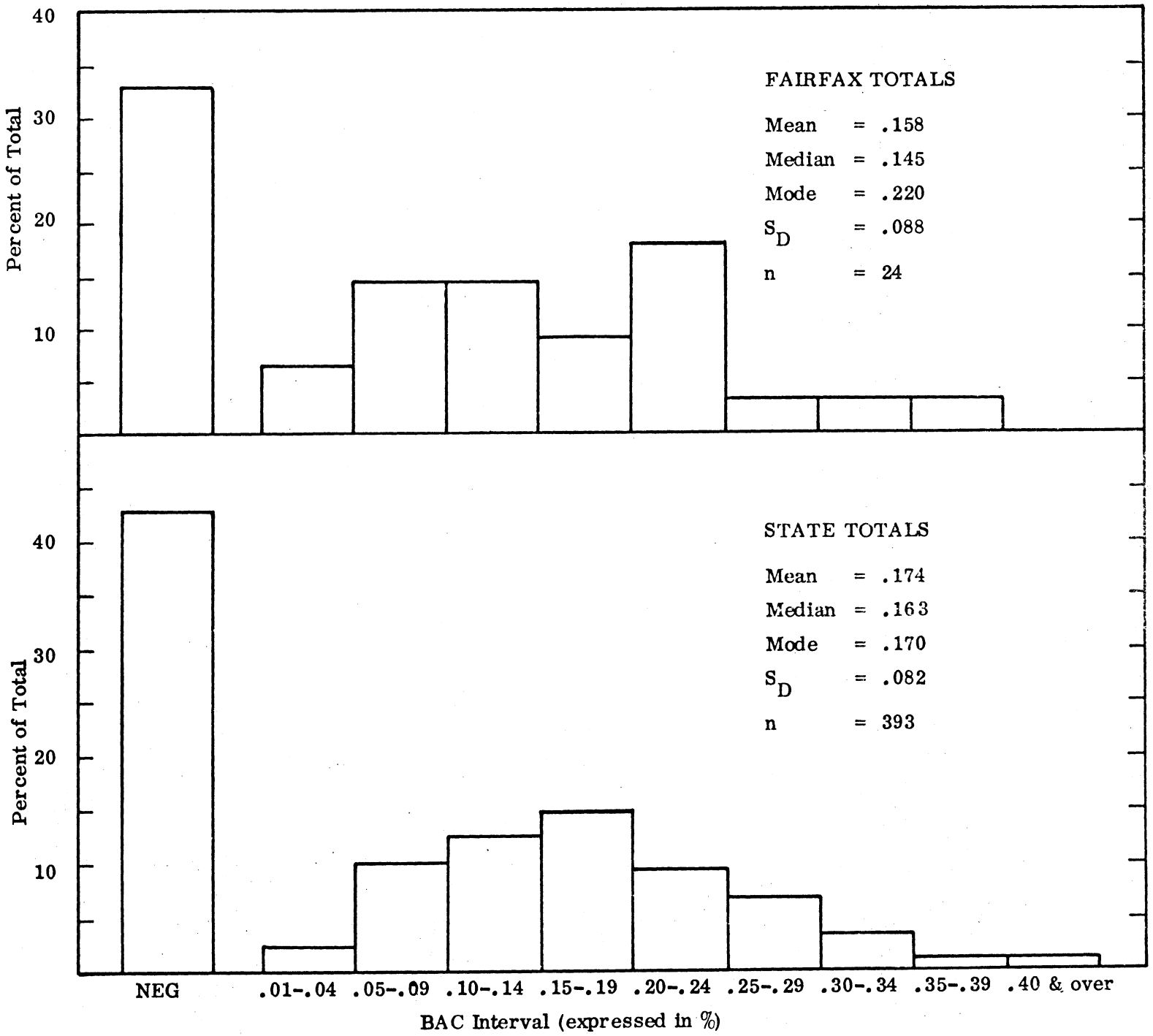

Figure 7. Motor vehicle deaths with alcohol tests, 1967.

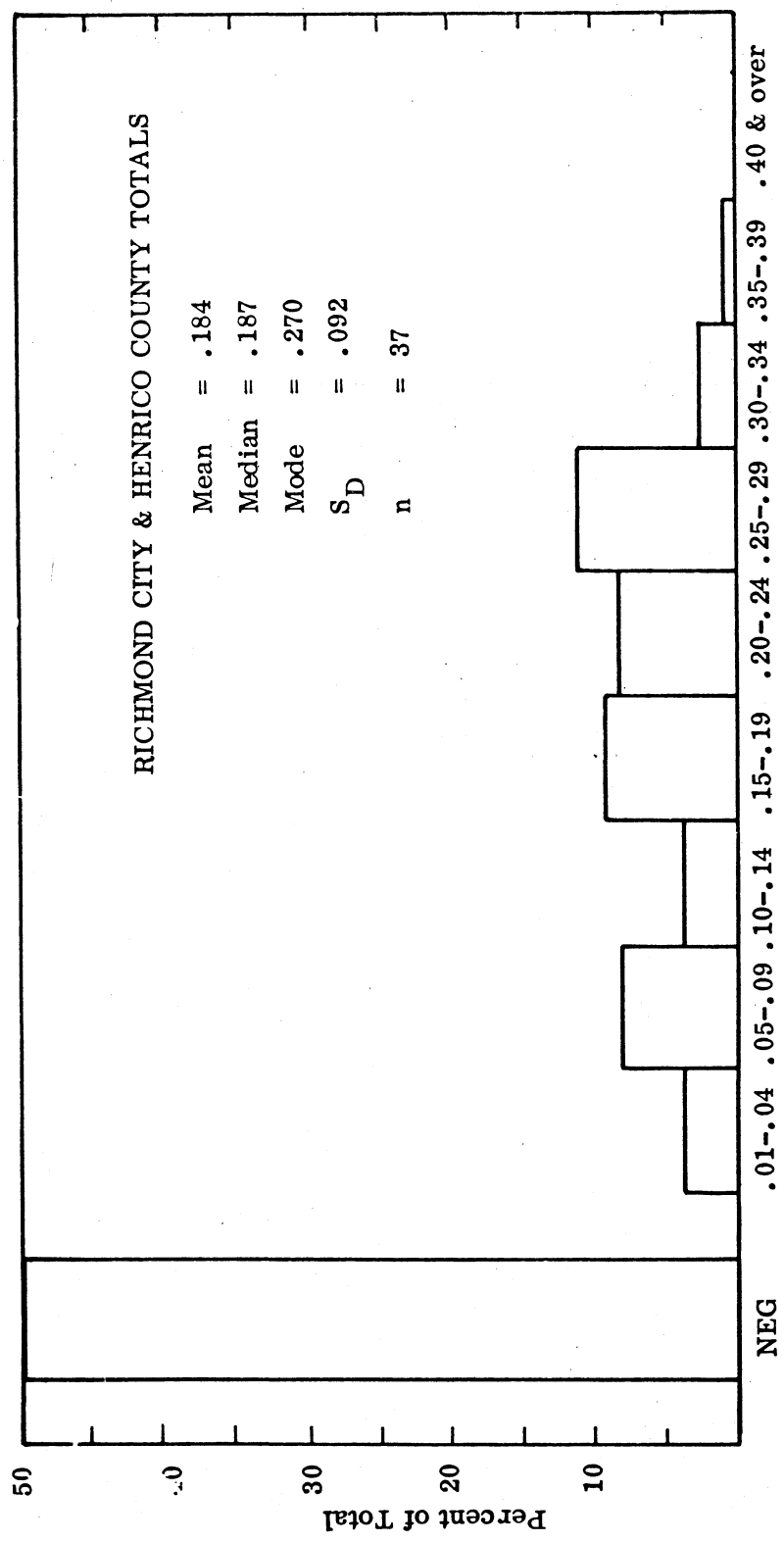

Figure 8. Motor vehicle deaths with alcohol tests, 1971.

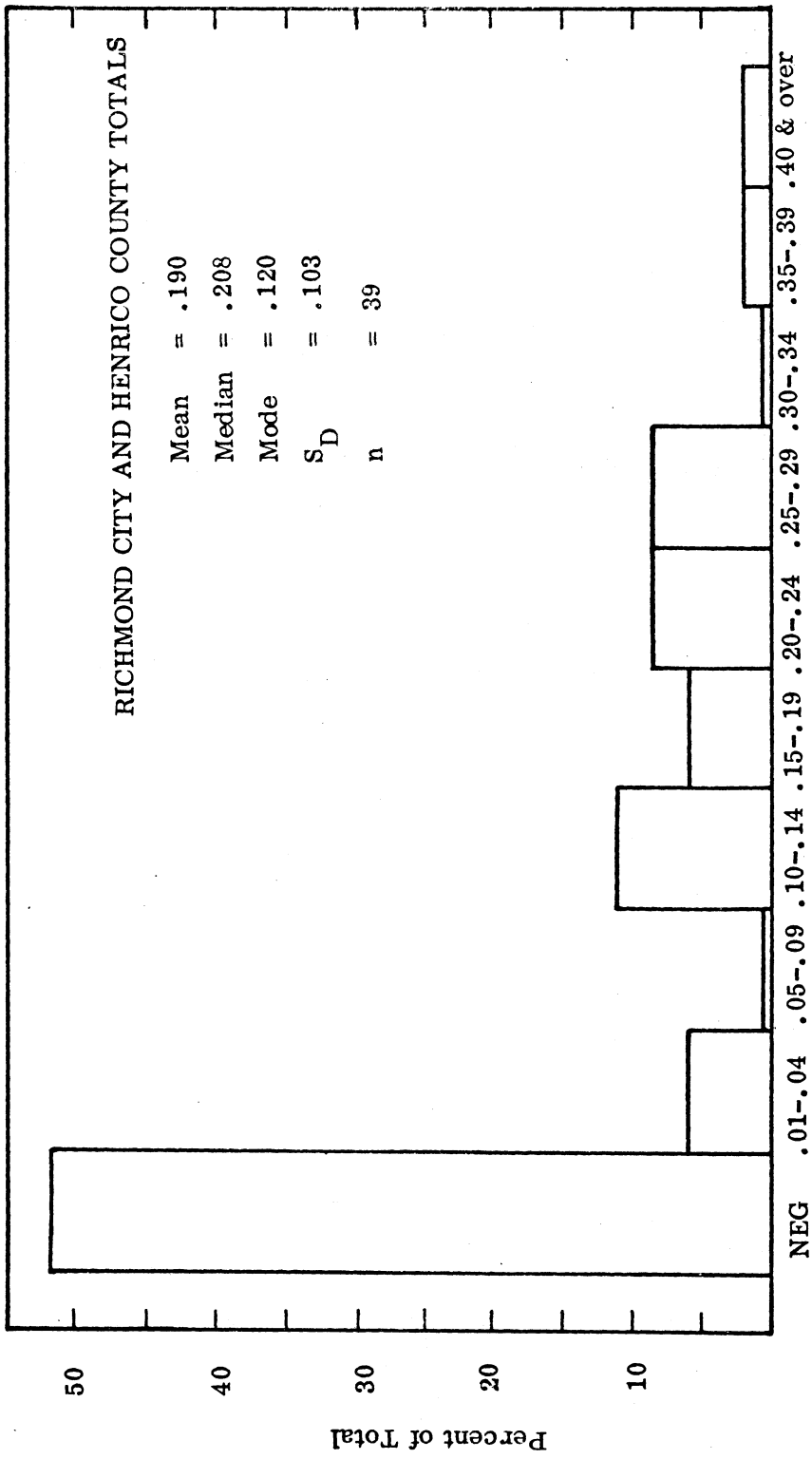

Figure 9. Motor vehicle deaths with alcohol tests, 1970.

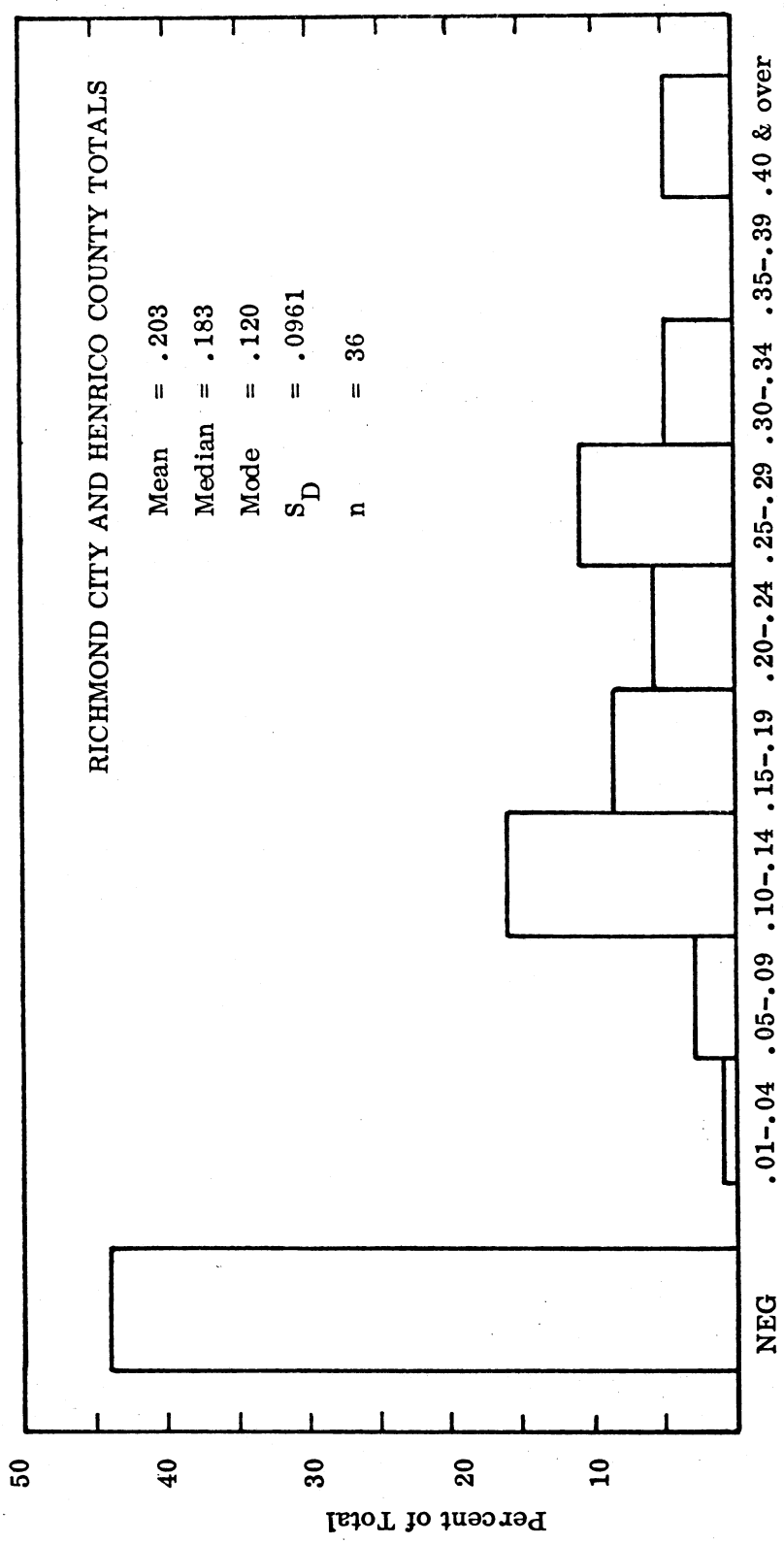

Figure 10. Motor vehicle deaths with alcohol tests, 1969.

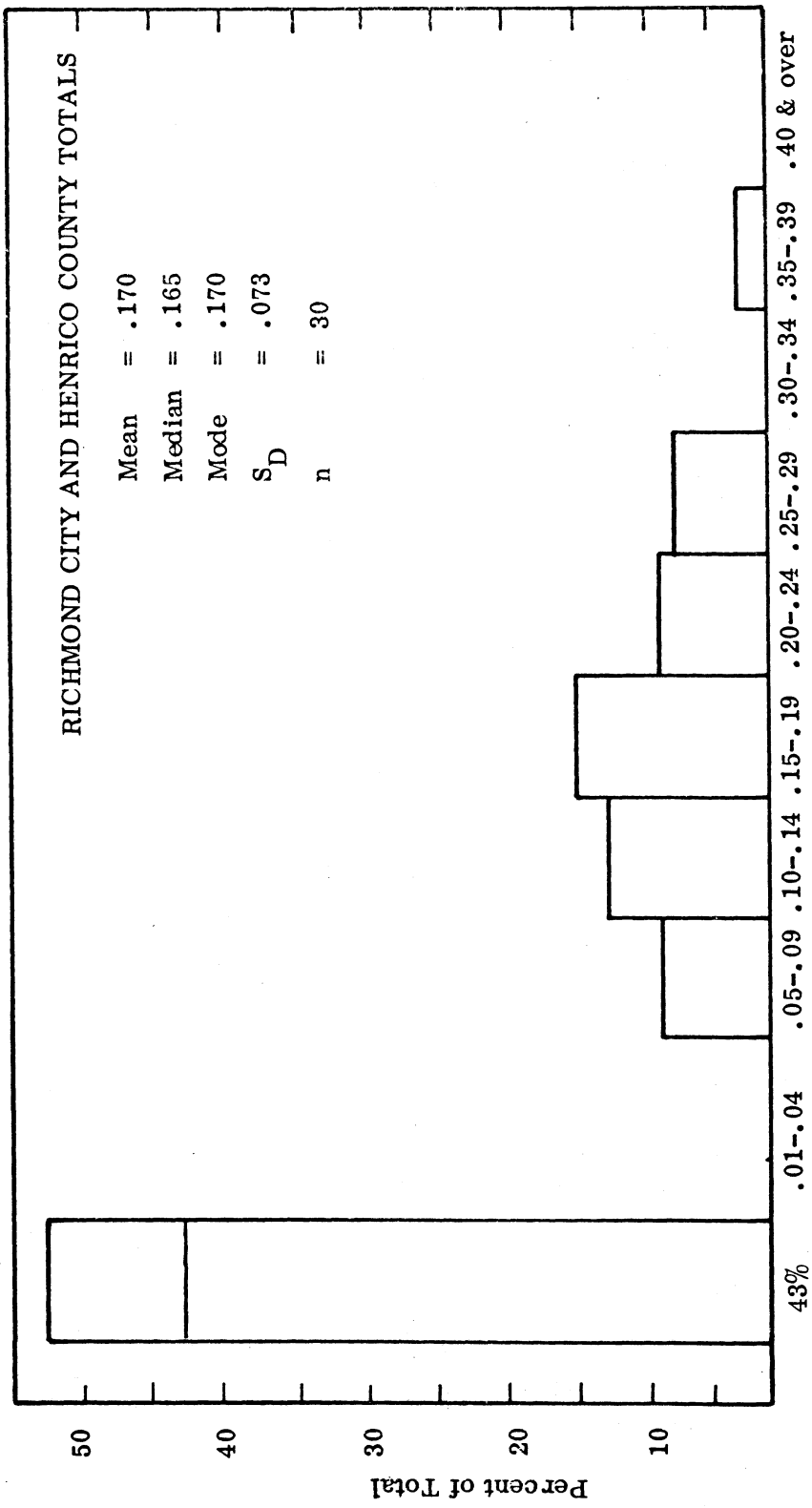

Figure 11. Motor vehicle deaths with alcohol tests, 1968.

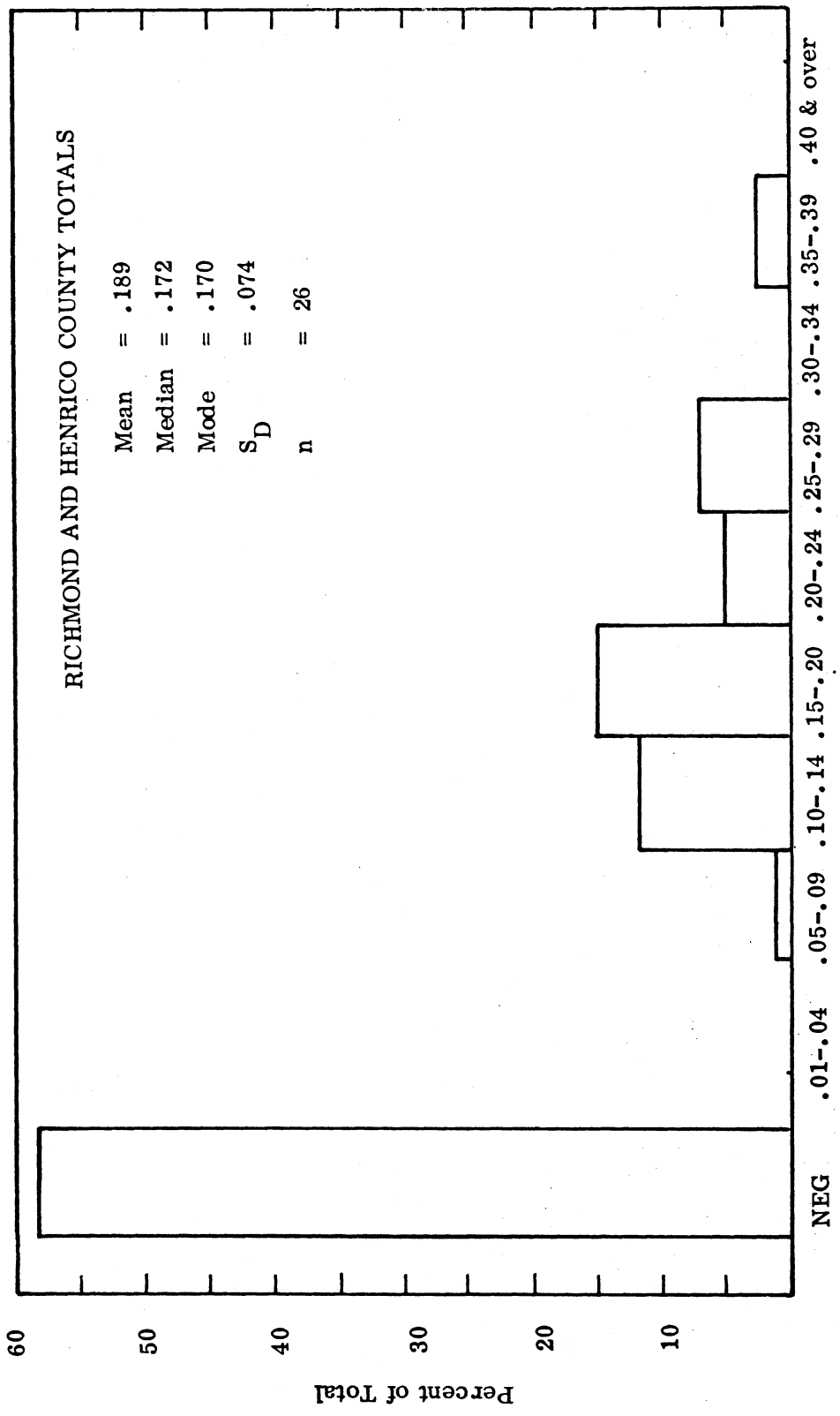

Figure 12. Motor vehicle deaths with alcohol tests, 1967.

This decision was made since it was felt that a change in the positive BAC distribution in Fairfax might occur gradually over the life of the ASAP, and that the change might not be significant on a year-to-year basis. In order to account for this possible circumstance, the Henrico/Richmond sample was chosen as a control. It should be noted that the method of analysis just described is designed to detect a change in the positive BAC distribution. This means that an increase in the negative BAC category is not taken into account, and it should be recognized that the negative BAC category could increase on a percentage basis, while the positive BAC distribution experienced no shift in statistical parameters. Certainly an increase in the percent of negative BAC's could be considered a favorable result of ASAP, and this aspect should be kept in mind, as well as the testing procedure described here for positive BAC's.

Testing the Difference Between Mean Positive BAC's

The Fairfax sample means and the Henrico/Richmond sample means for the years 1967-1971 were tested for the difference between two sample means. The Student's "t" Distribution was used because of the smallness of the sample sizes. The calculated t was found by the formula

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sigma \sqrt{1/N_1 + 1/N_2}}$$

where

$$\sigma = \sqrt{(N_1 S_1^2 + N_2 S_2^2) / (N_1 + N_2 - 2)}$$

The results of the calculations are given in Table 3, where the calculated t value is compared with the t value from the Student's distribution for a 95% level of confidence. If the calculated t value was higher than the Student's distribution, it could be concluded that the difference was significant and it could be said with 95% confidence that the two samples were not drawn from the same population. As shown in the table, in each of the five years the calculated t is lower than the Student's t, and thus it can be concluded that the Fairfax and Henrico/Richmond samples are drawn from the same population. By continuing this testing procedure over the life of the ASAP, it can be determined if a significant shift takes place in the positive BAC distribution.

The testing procedure described will be a much more powerful analytical tool when ASAP is applied on a statewide basis. The much larger state sample has very little variability, as opposed to the small county samples, and it will take a much smaller change in the statewide mean to be found significant. For this reason the state means can be tested against each other on a year-to-year basis, and small but important shifts in the positive BAC distributions can be detected.

Table 3

t-Values for Fairfax vs. Henrico-Richmond

	Calculated t	t.95
1971	.83	2.00
1970	.59	2.00
1969	1.87	2.00
1968	.69	2.01
1967	1.32	2.01

Establishing Expected BAC Mean

As was noted earlier, the analytical method described previously will test only for a shift in the positive BAC distribution and does not account for an increase in the percentage of negative BAC's. While it is felt that testing for a shift in the positive BAC distribution can yield important conclusions in an analysis of the ASAP, and the normally distributed nature of the positive BAC's easily lends itself to statistical analysis, it is also felt that an analysis of motor vehicle accident deaths with alcohol tests would not be complete without accounting for a possible significant increase in the percentage of negative BAC's. In order to take this factor into account, the mean of the Fairfax positive BAC distribution in each year was adjusted by the number of negative readings to yield a total mean of the motor vehicle accident deaths with alcohol tests, shown in Table 4. The average of these five means is equal to .091% with a standard deviation of .0164%. The standard error of the means is then equal to $.0164 / \sqrt{n} = .007$, and adopting a 95% confidence interval, a mean of Fairfax motor vehicle accident deaths with alcohol tests would be expected to fall in the interval .091 plus or minus 2.78 (from Student's t distribution) standard errors (.070 to .111%). If during the ASAP a mean falls outside this interval, it can be concluded that a significant change has taken place in the mean BAC level of motor vehicle accident victims in Fairfax. This method of analysis accounts for a possible increase in the percent of negative BAC's, which would certainly be considered a favorable impact in evaluating the ASAP.

Table 4

Fairfax Motor Vehicle Accident Deaths With Alcohol Tests
(Yearly Means of Total BAC's)

	Mean of Positive	# Positive	# Negative	Mean of Total
1971	.166%	42	29	.098%
1970	.176%	23	24	.086%
1969	.152%	16	22	.064%
1968	.185%	20	17	.100%
1967	.158%	24	12	.105%

Significance of Shift in BAC Distribution

Since the two analytical tests described thus far involve the use of means, it is possible that a shift in the BAC distribution would occur which would not affect the mean and go undetected. In order to detect these possible shifts in the BAC distribution and make the analysis of motor vehicle accident deaths with alcohol tests complete, it is felt that a chi-square test can be used effectively. The chi-square test will determine if the shift in the BAC distribution is significant, and then a subjective decision must be made as to whether the shift is desirable or undesirable. A composite of the 1967-1971 Fairfax data can be used as the base distribution, and the BAC distribution for each year of the ASAP can be tested against this base, as shown in Table 5.

Table 5

Method of Testing ASAP Distribution for Given Year
Against Baseline Distribution

BAC Interval (%)	Baseline Distribution (1967-1971 Composite)	BAC Distribution Any ASAP Year
Negative	104	X
.01-.04	6	X
.05-.09	22	X
.10-.14	25	X
.15-.19	24	X
.20-.24	29	X
.25-.29	10	X
.30-.34	5	X
.35-.39	3	X
.40 & Over	1	X

The null hypothesis to be tested is that the BAC readings are similarly distributed over the designated intervals in the two distributions. Applying the standard chi-square test will determine if any difference between the two distributions is significant or due to chance alone. It is important to note that any interval which does not contain five or more BAC tests must be combined with adjacent intervals to allow proper application of the chi-square test. Since the yearly ASAP distributions will be much smaller than the five year composite, certain combinations and adjustments will probably have to be made each year to provide a valid chi-square test.

CONCLUSIONS

This study has shown that the Virginia Chief Medical Examiner's alcohol tests of persons killed in motor vehicle accidents can be used as a tool to evaluate the ASAP through three analytical approaches. Given the normally distributed nature of positive BAC's, results of Fairfax and Henrico/Richmond can be used to test for the difference between means to determine if a significant shift in the positive BAC distribution in Fairfax has occurred. Also, a significant shift in the number of negative BAC's in Fairfax can be accounted for by using the results of the last five years to predict an expected mean of all alcohol tests on motor vehicle accident fatalities and a confidence interval around this expected mean. Finally, a chi-square test can be used to detect a significant shift in the BAC distribution which could occur without affecting the mean. Even though the motor vehicle accident deaths with alcohol tests in Fairfax and Henrico/Richmond are relatively small in magnitude and thus subject to variability, it is felt that application of the described techniques may prove useful in the evaluation of the ASAP. The study further indicates that once ASAP's are implemented on a statewide basis, the evaluation techniques developed will become much more useful in detecting significant shifts in the BAC distribution. This result will be true because the large number of state observations provide an extremely consistent and closely defined pattern in which small yet significant changes can be easily detected.

Appendix A is a preliminary evaluation of the BAC distributions of the first year of the Fairfax ASAP in which the analytical techniques previously described were applied to the data received thus far.

APPENDIX A

1972 BAC TEST RESULTS

The BAC test results of motor vehicle accident deaths in the Fairfax ASAP have been received for 1972, the first year of the ASAP, and are summarized in Table A-1.

TABLE A-1

ALCOHOL TEST RESULTS
(BAC Intervals Expressed in Percentages)

	Total	Negative	.01-.04	.05-.09	.10-.14	.15-.19	.20-.24	.25-.29	.30-.34	.35-.39	.40 & over
Motorcycle	1	0	0	0	0	1	0	0	0	0	0
Motor Vehicle Driver	38	19	2	0	5	3	7	0	2	0	0
Motor Vehicle Passenger	9	6	1	0	0	1	1	0	0	0	0
Motor Vehicle Pedestrian	17	13	0	0	0	2	0	1	0	0	1
Total	65	38	3	0	5	7	8	1	2	0	1

Since BAC test results of motor vehicle accident deaths in 1972 have not been obtained for the Henrico/Richmond area, only two of the three analytical techniques developed can be applied to the above data.

Comparison of Total BAC Means

The 1967-1971 average total (both positive and negative) BAC mean was found to be .091%, with a standard error of the means of .007%. The 95% confidence interval yielded an interval from .070% to .111% in which the total BAC mean could be expected to fall. The total BAC mean is .076%, which falls inside the established interval. Thus the null hypothesis, which says that no difference exists between the 1972 total BAC mean and the baseline period total mean, cannot be rejected. However, it is important to note that the 1972 total BAC mean breaks a three year trend in which the total BAC mean was increasing, and that if a change of the same magnitude and direction is experienced in 1973, the shift in the total BAC mean will become statistically significant.

Comparison of BAC Distributions

In order to test for a significant shift in the total BAC distribution, a chi-square test was applied to the data in Table A-2, where BAC categories have been combined such that at least five observations are in each cell.

Table A-2

TOTAL BAC TEST RESULTS
(BAC Intervals Expressed in Percentages)

	Negative .01-.04, .05-.09	.10-.14	.15-.19	.20 & over	Row Total
1972 ASAP	41	5	7	12	65
Baseline Distribution	132	25	24	48	229
Column Total	173	30	31	60	294

The calculated $X^2 = .926$ as compared to $X^2_{.95} = 7.81$, and thus the hypothesis that the BAC test results are similarly distributed in the 1972 ASAP year and the baseline distribution cannot be rejected, and any shift observed in the BAC distribution during 1972 could have occurred by chance alone.

In order to complete the analysis of motor vehicle accident deaths with alcohol tests for the 1972 ASAP, it will be necessary to obtain the test results for the Henrico/Richmond area in 1972, and then test for a difference of two means between the Fairfax and Henrico/Richmond area. Based strictly on the data obtained thus far, on which two of the analytical techniques were used, no statistical significance can be placed on the changes occurring in the Fairfax ASAP area in 1972 as reflected in motor vehicle accident deaths with alcohol tests.