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ANALYSIS OF TEXAS SKID DATA

Submitted to:

Federal Highway Administration
Office of Research & Development
400 Seventh Street, S. W.
Washington, D. C. 20591

Under:

Purchase Order No. 3-1-1003
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Submitted by:

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Mrs. Julie Anna Fee
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Dear Mrs. Fee:

I am pleased to transmit the enclosed final report on "The Analysis of Texas Skid Data". This report is submitted according to the terms of Purchase Order No. 3-1-1003, dated December 19, 1972 and satisfies all requirements listed there. The report is original copy and ready for duplication.

If there are any questions concerning this report, please let me know. It has been a pleasure working with you on this study.

Sincerely,

Richard L. Beatty

Richard L. Beatty

Enclosure

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ANALYSIS OF TEXAS SKID DATA

1. SUMMARY

This analysis deals with 501 wet weather accidents which occurred in a ten-county area in Texas during the period from May 1968 through September 1969. The data used in this study was furnished by the Texas Highway Department and mainly concerns five variables observed at the scene of the accident. These are, as follows:

(i) speed of the vehicle(s) immediately prior to the accident,

(ii) tire pressure(s) of the tires on the accident vehicles,

(iii) tread depth(s) of the tires on the accident vehicles,

(iv) measure of pavement payment friction at the accident scene, and

(v) measure of pavement texture at the accident scene.

In addition to the accident data, an area sample of traffic, vehicles and highways was measured in the same ten-county area to establish standard parameters and distributions for these same five variables. The analyses reported here deal primarily with comparisons of descriptive characteristics of single-vehicle, accident-related variables with those same characteristics of the standard distributions.

Detailed discussions of the specific analytic techniques utilized are included in the main body of the report. The analytical results, however, can be summarized according to the types of comparisons involved. This is done as follows:

1. Comparisons of variables distributions imply that increased single-vehicle accident occurrence is associated with

   - low tire tread depths, and
   - low tire pressures, and
   - higher speeds immediately before the accident

2. Comparisons of the average or mean values of the single-vehicle accident variables with the standard means reveal that accident-involved vehicles have

   - lower tire pressures,
   - lesser tread depths, and
   - higher speeds, and

   that accident locations involve

   - lower pavement friction, and
   - lesser pavement texture.

3. Two-dimensional comparisons of the observed frequencies of accident variables relative to the standard medians reveal that disproportionately high numbers of accidents occur with combinations of

   - high speed with low pavement friction, and
   - low tread depth with less pavement texture.

2. BACKGROUND

Between May 1968 and September 1969, the Texas Highway Department (THD) with the cooperation of the Texas Department of Safety, investigated 501 wet weather accidents in a ten-county area of the State. Five variables related to either the vehicle(s) or the pavement were selected for analysis: speed of the vehicle(s) at or immediately prior to the accident, pressure and tread depth of the vehicle tires, and pavement friction and texture at the accident site. To establish a control group for purposes of comparison, independent observations on the five variables were collected from a sample of pavement and non-accident vehicles in the ten-county area. Measures computed on the area sample are considered as the standard values in both this and the THD analysis.

The analysis techniques utilized in the THD report[1] included comparisons of the cumulative density functions for accident values versus the standard (area sample) values for each of the five variables. Also used was a simple comparison of percentages of observed accident values for each variable relative to the standard or area sample medians. Finally an analysis of variance technique was applied to accident frequencies with each variable observed on the accident dichotomized as + or - according to its value relative to the standard median.

This report constitutes some further analyses of the original five variables. However, unlike the THD study, the

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1 The Degree of Influence of Certain Factors Pertaining to the Vehicle and the Pavement on Traffic Accidents under Wet Conditions, Kenneth D. Hankins, et al, Texas Highway Department, Report Number 133-3F, September, 1970.

smallest unit of interest here is the accident vehicle(s) rather than the accident. Thus, this report considers 662 vehicles involved in the 501 wet weather accidents. A vehicle is classified according to whether it was involved in a single or multivehicle accident rather than by the THD scheme which involved categorizing the accidents into nine accident types. Nonetheless, the categories are roughly comparable: types 1, 2, 4, and 6 of the THD study comprise single vehicle accidents; type 5 compares to multivehicle accidents; and type 9 to all accidents. Definitions for all types are included in this report as Table A-1 on page 24. In keeping with the precedent set by the THD, accident vehicles with more than four tires and vehicles driven by drinking drivers have been omitted from the analyses, resulting in a total of 564 eligible vehicles.

The original accident data as collected by THD included a number of variables not discussed here. The original data was condensed into a data record of a single card image per accident-involved vehicle. The format of this record is depicted in Table 1 on page 6. In addition to the recorded speed and observed friction coefficient at the scene of the accident, the average tire pressure (in pounds), the average tread depth (in thirty-seconds of an inch) and a pavement texture value (average number of peaks divided by 29) was calculated for each of the vehicles in the data bank. Also, each of these five single values was compared to the median value of the area or standard and a + or - was assigned according to whether it was above or below this standard median.

Summaries of the data on accident vehicles and the area samples are given in Tables 2, 3 and 4. These Tables appear on pages 7 through 14. Table 2 presents the comparison of the data on accident vehicles and the standard median values. The percent above and below the median is given for each accident type. Also included are the comparable percentages published in the THD study.

The differences between the THD and the Westat percentages are due in part to different types of data points but are otherwise unexplained. Recall that a data point in the present report is associated with an accident-involved vehicle while that in the THD report was associated with the entire accident. There is no computational detail available on the THD data.

Table 3 presents summary or descriptive statistics on each of the five variables by accident type and includes the same statistics for the area or standard data. Table 4 presents the actual frequency distributions in terms of both counts and percentages including the breakdown into both accident types. Also included in Table 4 are the distributions, as available, using the area sample data.

Table 1

Card Format of Condensed Data Record
As Created by Westat

Columns	Description
1-6	accident number
8-9	vehicle number
11-12	vehicle model
14-15	speed before accident
17-18	drinking driver status
20-21	number of vehicles involved in accident
23-24	left front tire pressure
26-27	right front tire pressure
29-30	right rear tire pressure
32-33	left rear tire pressure
35-36	left front tread depth
38-39	right front tread depth
41-42	right rear tread depth
44-45	left rear tread depth
47-48	coefficient of friction at accident site
50-51	average coefficient of friction
53-57	average tire pressure
59-63	average tread depth
65-70	texture
72	outcome of comparing vehicle speed with standard median
73	outcome of comparing average pressure with standard median
74	outcome of comparing average tread depth with standard median
75	outcome of comparing coefficient of friction at accident site with standard median
76	outcome of comparing texture with standard median

Blank fields in columns 1-51 were filled with -1 (Note that -1 in columns 20-21 indicates a single vehicle accident.)

Table 2

Percentage of vehicles falling above and below median value of the area sample: A comparison of Texas Highway Department (THD) and Westat results

Variable	Single Vehicle (Types 1,2,4,6)		Multivehicle (Type 5)		Total (Type 9)	
	THD	Westat	THD	Westat	THD	Westat
- Speed	36.5	39.5	78.6	73.7	46.5	56.4
+ Speed	63.5	60.5	21.4	26.3	53.5	43.6
- Pressure	40.5	56.3	33.9	38.4	37.4	47.5
+ Pressure	59.5	43.7	66.1	61.6	62.6	52.5
- Tread	66.8	69.8	26.8	47.8	55.8	59.0
+ Tread	33.2	30.2	73.2	52.2	44.2	41.0
- Friction	64.7	65.7	73.2	73.3	62.6	69.4
+ Friction	35.3	34.3	26.8	26.7	37.4	30.6
- Texture	67.9	68.9	64.3	61.0	64.9	64.9
+ Texture	32.1	31.1	35.7	39.0	35.1	35.1

Table 3

Descriptive statistics on all variables for single and multivehicle accidents with comparable area sample data

Accident Variable and Statistic	Single Vehicle Accidents	Multivehicle Accidents	Total Accidents
SPEED (mph)			
Number of observations	286	278	564
Mean	53.95	36.22	45.21
Median	55.00	40.00	50.00
Standard deviation	11.34	21.00	18.99
PRESSURE (pounds)			
Number of observations	286	276	562
Mean	25.38	28.16	26.75
Median	27.00	28.92	27.92
Standard deviation	5.45	5.83	5.80
TREAD (32nd inch)			
Number of observations	285	276	561
Mean	5.44	6.81	6.12
Median	5.49	7.15	6.29
Standard deviation	2.63	2.71	2.75
FRICTION (skid number)			
Number of observations	254	240	494
Mean	34.95	34.13	34.55
Median	35.00	34.06	34.51
Standard deviation	8.44	7.19	7.86
TEXTURE (inches/29 inches)			
Number of observations	264	269	533
Mean	0.66	0.76	0.71
Median	0.48	0.65	0.58
Standard deviation	0.63	0.66	0.65

Table 3 (cont.)

Descriptive statistics on all variables for single and multivehicle accidents with comparable area sample data

3B. Area Sample Data

Variable	Number of Observations	Mean	Median	Standard Deviation
Speed	425	52.79	53.95	10.29
Pressure	1,131	27.53	28.00	4.86
Tread	2,288	6.30	7.00	2.84
Friction	380	32.51	38.04	9.42
Texture	4,331,350	0.92	0.87	0.82

Table 4

Relative and actual frequency distributions for all variables and for single and multivehicle accidents with comparisons to area sample

4A. Speed

Speed (mph)	Single Vehicle Accidents			Multivehicle Accidents			Total			Area Sample		
	f	%	Cum %	f	%	Cum %	f	%	Cum %	f	%	Cum %
0-9.99	1	0.4	0.4	40	14.4	14.4	41	7.3	7.3	0		
10-19.99	1	0.4	0.8	27	9.7	24.1	28	5.0	12.3	0		
20-29.99	2	0.7	1.5	27	9.7	33.8	29	5.1	17.4	7	1.7	1.7
30-39.99	20	7.0	8.5	22	7.9	41.7	42	7.4	24.8	43	10.1	11.8
40-49.99	51	17.8	26.3	52	18.7	60.4	103	18.3	43.1	103	24.2	36.0
50-59.99	75	26.2	52.5	59	21.2	81.6	134	23.8	66.9	164	38.6	74.6
60-69.99	114	39.9	92.4	48	17.3	98.9	162	28.7	95.6	100	23.5	98.1
70-79.99	21	7.3	99.7	3	1.1	100.0	24	4.3	99.9	8	1.9	100.0
80-89.99	1	0.4	100.1	0			1	0.2	100.1	0		
Total	286	100.0		278	100.0		564	100.0		425	100.0	

Table 4 (cont.)

Relative and actual frequency distributions for all variables and for single and multivehicle accidents with comparisons to area sample

4B. Pressure (pounds)

Pressure	Single Vehicle Accidents			Multivehicle Accidents			Total			Area Sample		
	f	%	Cum %	f	%	Cum %	f	%	Cum %	f	%	Cum %
< 12	7	2.4	2.4	1	0.4	0.4	8	1.4	1.4	1	0.1	0.1
12-14.99	4	1.4	3.8	0			4	0.7	2.1	8	0.7	0.8
15-17.99	20	7.0	10.8	4	1.4	1.8	24	4.3	6.4	18	1.6	2.4
18-20.99	25	8.7	19.5	16	5.8	7.6	41	7.3	13.7	58	5.1	7.5
21-22.99	29	10.1	29.6	18	6.5	14.1	47	8.4	22.1	86	7.6	15.1
23-24.99	23	8.0	37.6	25	9.1	23.2	48	8.5	30.6	119	10.5	25.6
25-26.99	35	12.2	49.8	28	10.1	33.3	63	11.2	41.8	150	13.3	38.9
27-28.99	52	18.2	68.0	48	17.4	50.7	100	17.8	59.6	218	19.3	58.2
29-30.99	69	24.1	92.1	77	27.9	78.6	146	26.0	85.6	228	20.2	78.4
31-32.99	17	5.9	98.0	39	14.1	92.7	56	10.0	95.6	129	11.4	89.8
33-35.99	4	1.4	99.4	11	4.0	96.7	15	2.7	98.3	73	6.5	96.3
36-38.99	0			3	1.1	97.8	3	0.5	98.8	27	2.4	98.7
39-41.99	0			3	1.1	98.9	3	0.5	99.3	8	0.7	99.4
> 41.99	1	0.3	99.7	3	1.1	100.0	4	0.7	100.0	8	0.7	100.1
Total	286	100.0		276	100.0		562	100.0		1,131	100.0	

Table 4 (cont.)

Relative and actual frequency distributions for all variables and for single and multivehicle accidents with comparisons to area sample

4C. Tread (32nds of inch)

Tread	Single Vehicle Accidents			Multivehicle Accidents			Total			Area Sample		
	f	%	Cum %	f	%	Cum %	f	%	Cum %	f	%	Cum %
0-0.99	9	3.2	3.2	4	1.4	1.4	13	2.3	2.3	66	2.0	2.9
1-1.99	21	7.4	10.6	5	1.8	3.2	26	4.6	6.9	78	3.4	6.3
2-2.99	18	6.3	16.9	18	6.5	9.7	36	6.4	13.3	129	5.6	11.9
3-3.99	31	10.9	27.8	16	5.8	15.5	47	8.4	21.7	144	6.3	18.2
4-4.99	45	15.8	43.6	24	8.7	24.2	69	12.3	34.0	186	8.1	26.3
5-5.99	38	13.3	56.9	31	11.2	35.4	69	12.3	46.3	256	11.2	37.5
6-6.99	37	13.0	69.9	34	12.3	47.7	71	12.7	59.0	237	10.4	47.9
7-7.99	34	11.9	81.8	39	14.1	61.8	73	13.0	72.0	320	14.0	61.9
8-8.99	22	7.7	89.5	40	14.5	76.3	62	11.1	83.1	323	14.1	76.0
9-9.99	14	4.9	94.4	24	8.7	85.0	38	6.8	89.9	269	11.8	87.8
10-10.99	6	2.1	96.5	24	8.7	93.7	30	5.3	95.2	168	7.3	95.1
11-11.99	7	2.5	99.0	12	4.3	98.0	19	3.4	98.6	82	3.6	98.7
12-12.99	3	1.1	100.1	2	0.7	98.7	5	0.9	99.5	23	1.0	99.7
13-13.99	0			2	0.7	99.4	2	0.4	99.9	4	0.2	99.9
14-14.99	0			0			0			3	0.1	100.0
15-15.99	0			1	0.4	99.8	1	0.2	100.1	0		
Total	285	100.0		276	100.0		561	100.0		2,288	100.0	

Table 4 (cont.)

Relative and actual frequency distributions for all variables and for single and multivehicle accidents with comparisons to area sample

4D. Friction (skid no.)

	Single Vehicle Accidents			Multivehicle Accidents			Total			Area Sample		
Friction	f	%	Cum %	f	%	Cum %	f	%	Cum %	f	%	Cum %
10-14	1	0.4	0.4	1	0.4	0.4	2	0.4	0.4	0		
15-19	2	0.8	1.2	2	0.8	1.2	4	0.8	1.2	0		
20-24	22	8.7	9.9	15	6.2	7.4	37	7.5	8.7	12	3.2	3.2
25-29	38	15.0	24.9	46	19.2	26.6	84	17.0	25.7	52	13.7	16.9
30-34	64	25.2	50.1	69	28.7	55.3	133	26.9	52.6	81	21.3	38.2
35-39	71	28.0	78.1	55	22.9	78.2	126	25.5	78.1	74	19.5	57.7
40-44	28	11.0	89.1	27	11.2	89.4	55	11.1	89.2	71	18.7	76.4
45-49	14	5.5	94.6	17	7.1	96.5	31	6.3	95.5	47	12.4	88.8
50-54	6	2.4	97.0	8	3.3	99.8	14	2.8	98.3	18	4.7	93.5
55-59	6	2.4	99.4	0			6	1.2	99.5	12	3.2	96.7
60-64	1	0.4	99.8	0			1	0.2	99.7	9	2.4	99.1
65-69	1	0.4	100.2	0			1	0.2	99.9	4	1.1	100.2
Total	254	100.0		240	100.0		494	100.0		380	100.0	

Relative and actual frequency distributions for all variables and for single and multivehicle accidents with comparisons to area sample

4E. Texture * (average number of peaks divided by 29)

Texture	Single Vehicle Accidents			Multivehicle Accidents			Total			Area Sample		
	f	%	Cum %	f	%	Cum %	f	%	Cum %	f	%	Cum %
0-.16	73	27.7	27.7	69	25.7	25.7	142	26.6	26.6	497,882	11.5	11.5
.17-.33	45	17.0	44.7	21	7.8	33.5	66	12.4	39.0	1,361,689	31.4	42.9
.34-.51	18	6.8	51.5	21	7.8	41.3	39	7.3	46.3	0		
.52-.67	22	8.3	59.8	29	10.8	52.1	51	9.6	55.9	0		
.68-.85	22	8.3	68.1	24	8.9	61.0	46	8.6	64.5	236,516	5.5	48.4
.86-1.02	17	6.4	74.5	12	4.5	65.5	29	5.4	69.9	929,830	21.5	69.9
1.03-1.19	8	3.0	77.5	22	8.2	73.7	30	5.6	75.5	419,643	9.7	79.6
1.20-1.37	16	6.1	83.6	23	8.6	82.3	39	7.3	82.8	0		
1.38-1.54	11	4.2	87.8	18	6.7	89.0	29	5.4	88.2	0		
1.55-1.71	15	5.7	93.5	15	5.6	94.6	30	5.6	93.8	45,570	1.1	80.7
1.72-1.89	9	3.4	96.9	4	1.5	96.1	13	2.4	96.2	92,310	2.1	82.8
1.90-2.06	2	0.8	97.7	3	1.1	97.2	5	0.9	97.1	59,749	1.4	84.2
2.07-2.23	1	0.4	98.1	0			1	0.2	97.3	0		
2.24-2.40	1	0.4	98.5	2	0.7	97.9	3	0.6	97.9	0		
2.41-2.58	1	0.4	98.9	2	0.7	98.6	3	0.6	98.5	611,570	14.1	98.3
2.59-2.75	1	0.4	99.3	0			1	0.2	98.7	0		
2.76-2.92	1	0.4	99.7	2	0.7	99.3	3	0.6	99.3	76,591	1.8	100.1
2.93-3.09	1	0.4	100.1	0			1	0.2	99.5	0		
3.10-3.26	0			2	0.7	100.0	2	0.4	99.9	0		
Total	264	100.0		269	100.0		533	100.0		4,331,350	100.0	

* Among accident values, f refers to number of vehicles. Among area sample values, f refers to daily vehicle miles of travel.

3. ANALYSES

3.1 Introduction

There are two preliminary points that should be made regarding the analysis. First, it is assumed throughout that the area or standard data results are parameters of the underlying variable universes and that the accident results are random samples taken from these universes. That is, the standard values are considered to be fixed, with all the sampling variation contained in the accident sample data. With the sample sizes as large as they are, there would be only negligible differences in the results if the sampling error in the area sample data were measured and used in the analysis.

The second point to be made concerns the comparisons involving measures on vehicles to be made in the analysis. It would seem that comparisons make sense with regard to vehicles involved in single vehicle accidents only. The multivehicle accidents involve two or more vehicles. Thus, all vehicle attributes represent some combination of values over more than one vehicle. Thus, the values may include situations that vary all the way from a head-on collision with both vehicles equally at fault to situations where at least one of the accident-involved vehicles was not even in motion at the time of the accident. A glance at the speed distributions for the two accident types as given in Table 4 bears out these comments. Hence, if relationships which might be causally related to skidding accidents are the target of interest, the confounding effects of combining vehicle measures should be avoided.

Thus, the following comments will be directed primarily toward the values determined on vehicles involved in single vehicle accidents. In every case, however, the tabled results will, for the reader's information, include values for total accidents as well as multi-vehicle accidents separately.

3.2 The Techniques

The primary method of analysis used in comparing the observed values of the five variables of interest with the standard values utilized non-parametric assumption with a chi-squared test statistic. Both contingency table analysis and goodness-of-fit tests were involved. These techniques use a computed chi-squared value to indicate the likelihood that an observed difference could have been due to sampling variability alone if the assumed relation were in fact, true. The expression of this likelihood is in terms of level of significance. For instance, if a computed chi-squared value is significant at the .01 level, this means that, under the assumed relationship, the observed difference(s) could have occurred by chance alone with probability less than .01. Most standard texts[2] discuss the method and theory of analysis of frequencies by chi-squared techniques.

The other analysis technique involves the computation of what is called a t-statistic. The use of this method assumes that the distribution of the sample mean is normal. With measurement data and the sample sizes considered in this study, this assumption is not restrictive.

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[2] Bryant, Edward C., Statistical Analysis, McGraw-Hill Book Company.

Significant values of the computed t-statistic are interpreted the same as for the computed chi-squared values discussed earlier. The significance level indicates the likelihood of the observed difference occurring by chance alone under the hypotheses.

3.3 Analysis Results

The initial analysis concerned Table 4 which appears on pages 10 - 14 and was mentioned earlier in this report. The three standard percentage distributions involving measures on vehicles were assumed to be population distributions and the percentages given were used to apply a goodness-of-fit test to the observed distributions regarding the accident-involved vehicles. In every case, the tests indicated that the sample distribution for vehicles involved in single vehicle accidents differed very significantly (level less than .001) from the population distributions. For both tread depth and tire pressure, the indications were that the accident-involved vehicles had higher relative occurrences at the lower end of the value scale with correspondingly lower frequencies for the higher values. That is, the accident-involved vehicles had a higher proportion of both low tread depths and low tire pressures than did the standard vehicle found in the area. The speed distribution for the vehicles had disproportionately high frequencies at the higher speeds, indicating a direct association between single vehicle accidents and higher-than-average speeds.

The differences between the arithmetic means of the measures on accidents and the means of the standard distributions formed the basis for the results presented in Table 5. It can be seen that, except for speed, the average of each measured value recorded on the single vehicle accidents was significantly (.01 level) less than the hypothesized population mean as measured by the area sample. This means that the chances are less than one in a hundred that the average tire pressure, tire tread depth, pavement friction and pavement texture are as much below the standard average values as observed due to sampling variation alone. In other words, each of the observed differences, under the hypothesis that the standard averages are, in fact, population parameters, would have occurred less than one time out of one hundred due to chance causes alone, if the observed values on single vehicle accidents were random samples selected from populations with the indicated means. For speed, the difference was in the reverse direction and significant at the .10 level only. Thus, the probability of a sample average speed being as high or higher than that observed due to chance alone, if the standard is the true average speed, was less than one in ten.

It is to be noted here that the standard speed distribution was obtained entirely from highways with posted speeds of 70 miles per hour. While the posted speed at the scene of the single vehicle accidents is unknown, it is highly likely that some unknown proportion occurred on highways with a lesser posted speed. Further, the determination of the speed of the accident-involved vehicle immediately prior to the accident, undoubtedly has a downward bias. Both of these conditions tend to bias the mean speed difference as recorded. Hence, it is very likely that the average speed of vehicles involved in single vehicle accidents is greater than the average vehicle on the road at that time with a true level of significance higher than indicated.

Tables 6 and 7 summarize the results of the contingency table analysis. All possible two- and three-way frequency tables were formed on the basis of whether the observed vehicle and pavement values for accidents were above or below the median of the standard values. The marginal totals for the frequency tables were used to compute the theoretical frequencies. The differences between the observed and theoretical frequencies were then utilized to obtain a computed chi-squared value. The computed chi-squared values for all these associations are presented in Tables 6 and 7. A designation of the level of significance is included for each.

The hypothesis being tested in each case is that of independence, or whether the proportion of one variable is equal at all levels of the other(s). Thus, in Table 6, the conclusion is that for single vehicle accidents, speed is not independent of friction nor is tread depth independent of texture. Stated another way, the results show that the proportion of accident-involved vehicles with higher- (or lower-) than-median speeds is not the same for both higher and lower friction values with similar conclusions on tread depth and pavement texture. Specifically these results indicate that a larger than expected number of accidents occur when high speed is combined with low pavement friction or when low tread depth is combined with a low peak frequency of pavement texture.

The results of the analysis summarized in Table 6 are logical and tend to reinforce the consensus feeling regarding contributors to accident occurrence. That is, that the combinations of high speeds with low pavement friction and shallow tread depth with low peak frequency of pavement texture lead to wet weather accidents.

The significant result indicated for the tire pressure-tread depth relationship for multivehicle accidents should be interpreted with caution because of the confounding. Examination of the accident data shows that low pressures are more prevalent with shallow treads and high pressure associates with the deeper treads.

From Table 7, it is seen that almost all of the three-way associations among variables measured on single vehicle accidents are significant. Little can be gained from investigation of the actual three-dimensional frequency tables. The implication from Table 7 seems to be that the relationship of the variables to accidents are multiply interactive, although there are clearly univariate and bivariate relationships of significance as indicated from earlier results.

It should be pointed out that, if a number of statistical tests are applied to the same set of data, some significant results might be expected even though there were no real differences. For instance, on the average, one in twenty (five percent) of all tests would be significant at the .05 level under conditions where no true differences existed. In the present research, many tests were applied to the same sample observations. There is no way to distinguish which, if any, of the indicated significant differences might truly be chance variations. The reader is simply cautioned about the high probability of at least one significant difference occurring by chance alone when a number of tests are applied to the same set of data.

Table 5

Area sample arithmetic means less accident-related means*
for all variables expressed in original units
and in t-statistic units

A. Differences in means original units

Variable	Single Vehicle Accidents	Multivehicle Accidents	Total
Speed	-1.16	16.57	7.58
Pressure	2.15	-0.63	0.78
Tread	0.86	-0.51	0.18
Friction	3.56	4.38	3.96
Texture	0.26	0.16	0.21

B. Computed t-statistics values

Variable	Single Vehicle Accidents	Multivehicle Accidents	Total
Speed	-1.73	13.15	9.48
Pressure	6.72	-1.80	3.25
Tread	5.38	-3.19	1.50
Friction	6.72	9.52	11.31
Texture	6.50	4.00	7.00

* A negative value indicates that the accident mean exceeded the area sample mean for that particular variable and accident type.

Table 6

Chi-squared values calculated on variables taken two at a time for single and multivehicle accidents

Variables Combination	Single Vehicle Accidents	Multivehicle Accidents	Total
Speed-Pressure	2.60	2.80	12.94***
Speed-Tread	1.06	0.71	9.12**
Speed-Friction	5.25*	0.87	2.57
Speed-Texture	1.51	0.13	0.19
Pressure-Tread	0.03	25.31***	18.55***
Pressure-Friction	0.95	1.89	3.84*
Pressure-Texture	1.40	0.42	0.00
Tread-Friction	0.38	0.06	1.00
Tread-Texture	4.58*	0.03	2.82
Friction-Texture	2.61	1.00	2.69

* Significant at .05 level

** Significant at .01 level

*** Significant at .001 level

Table 7

Chi-squared values calculated on variables taken three at a time for single and multivehicle accidents

Variables	Single Vehicle Accidents	Multivehicle Accidents	Total
Speed-Pressure-Tread	5.24*	27.69***	42.35***
Speed-Pressure-Friction	7.71**	8.60**	19.76***
Speed-Pressure-Texture	8.52**	4.19*	18.37***
Speed-Tread-Friction	8.29**	1.88	13.05***
Speed-Tread-Texture	6.04*	1.11	9.34**
Speed-Friction-Texture	9.31**	2.75	5.42*
Pressure-Tread-Friction	2.66	23.97***	23.71***
Pressure-Tread-Texture	5.90*	28.12***	17.89***
Pressure-Friction-Texture	4.02*	3.59	7.16**
Tread-Friction-Texture	9.21**	1.96	8.02**

* Significant at .05 level

** Significant at .01 level

*** Significant at .001 level

APPENDIX

Table A-1

Accident type descriptions from THD Report

(1) accidents occurring on a tangent or straight roadway section with no braking involved,

(2) accidents occurring on curves,

(4) accidents occurring on a tangent with braking involved,

(5) multiple vehicle accidents,

(6) accidents occurring while passing,

(7) miscellaneous accidents, and

(9) all of the above.