An Evaluation of the Effects Traffic Signals Have on Accidents

TSD-497-82

TRAFFIC and SAFETY DIVISION

MICHIGAN DEPARTMENT OF TRANSPORTATION

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By

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TABLE OF CONTENTS

ABSTRACT

This study evaluates the effects of the installation of traffic signals in 1976, 1977, and 1978 on accidents at 39 intersections under the jurisdiction of the Michigan Department of Transportation. Accident experience at these intersections was examined for a two-year "before" and a two-year "after" period. Accident experience during the year of installation was omitted.

The total number of accidents increased 25 percent, from 704 to 882. Angle accidents decreased 27 percent (293 to 215), left-turn accidents increased 86 percent (85 to 158), rear-end collisions were up 126 percent (120 to 271), and miscellaneous accidents (sideswipes, parking, etc.) increased 16 percent (206 to 238). Fatal accidents dropped from 2 to 1. The number of personal injuries increased 16 percent (injury accidents increased 23 percent). Property damage only accidents rose 27 percent.

A statistical analysis of the changes in accidents is contained in the Appendix. The 25 percent increase in total accidents is attributed to the signal installations at the 99 percent confidence level using the Student t test.

LIST OF FIGURES

INTRODUCTION

This study was undertaken in response to a need for updated information on the effects of traffic control signalization on accidents.* The report was also conducted for credit as an independent study course at Michigan State University under the guidance of Dr. William Taylor, Chairman of the Civil Engineering Department. The department's last published report on this subject was done by Max Clyde, P.E., of the Traffic Division (now Traffic and Safety), and was published in the November 1964, issue of Traffic Engineering (now ITE Journal) magazine. That study showed total accidents increased 34 percent (621 to 830), right-angle type accidents decreased 45 percent (242 to 134), rear-end type accidents increased 98.5 percent (259 to 514). Division personnel examined this subject in the intervening years and found the same general accident trends; therefore, no formal reports were published.

Records were examined to identify all state trunkline intersections which had traffic signals installed during 1976, 1977, and 1978. Only those intersections experiencing no other major changes during the study period were selected for analysis. The accident histories of these intersections were then obtained. A summary of resultant data can be found on Figures 1 through 4.

The Appendix contains the statistical analyses (Student t tests) conducted to determine the levels of confidence relative to the change in accidents due to signalization rather than to chance.

This report assumed that negligible changes in traffic volume occurred over the study period (i.e. Average Daily Traffic before = Average Daily Traffic after) so direct comparisons could be made of the numbers of accidents over like-time spans at each intersection.

Each intersection was examined using two calendar years of data before-and-after the installation of the signal. The calendar year in which the signal was installed was omitted to allow time for motorists' adjustment to a new traffic device, as well as to simplify data gathering.

*Throughout this report, "traffic signals" refers to stop-and-go traffic signals.

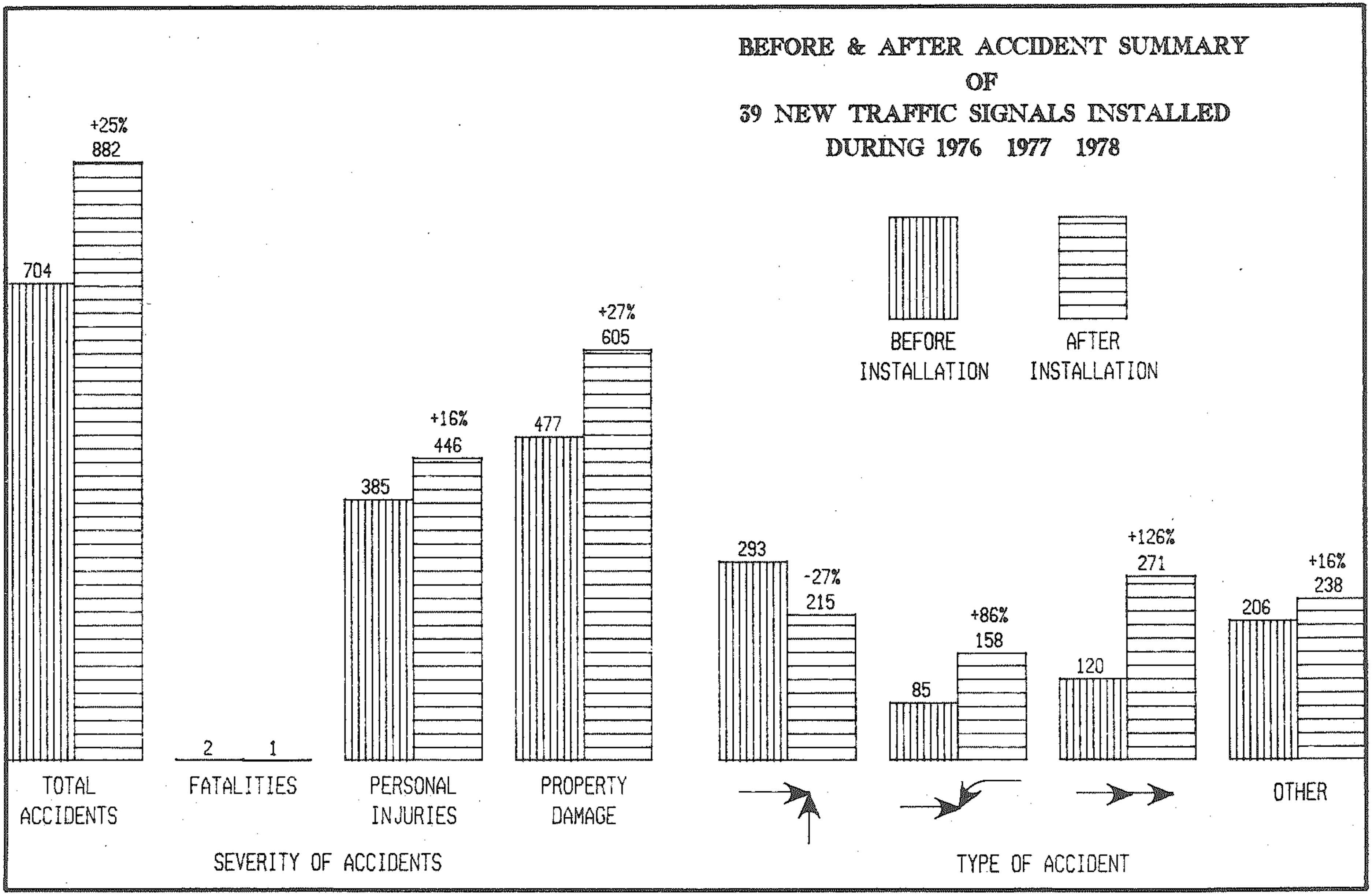
Data Gathering Procedure

Once the list of intersections was developed, data gathering began. The accident-master file was used to obtain the accident data, and MIDAS* was used as a check on the accuracy of the data actually utilized. This cross inspection functioned as a check for transcription and typographical errors, as well as for mistakes in records.

All accidents within 100 feet of the center intersection were considered to be under the influence of the intersection and were included in the accident totals.

The before-and-after accident studies (Figure 1) are graphical representations of the total number of accidents in the two-year before and two-year after periods at the 39 study locations. The accidents are summarized into two categories: type of accident (right-angle, left-turn, rear-end, or other) and severity of accident (fatalities, injuries, or property damage only). From these graphs, it can be seen that accidents increased in nearly all categories.

*MIDAS - Michigan Dimensionalized Accident Surveillance System.



BEFAFTACC 04068222

FIGURE 1

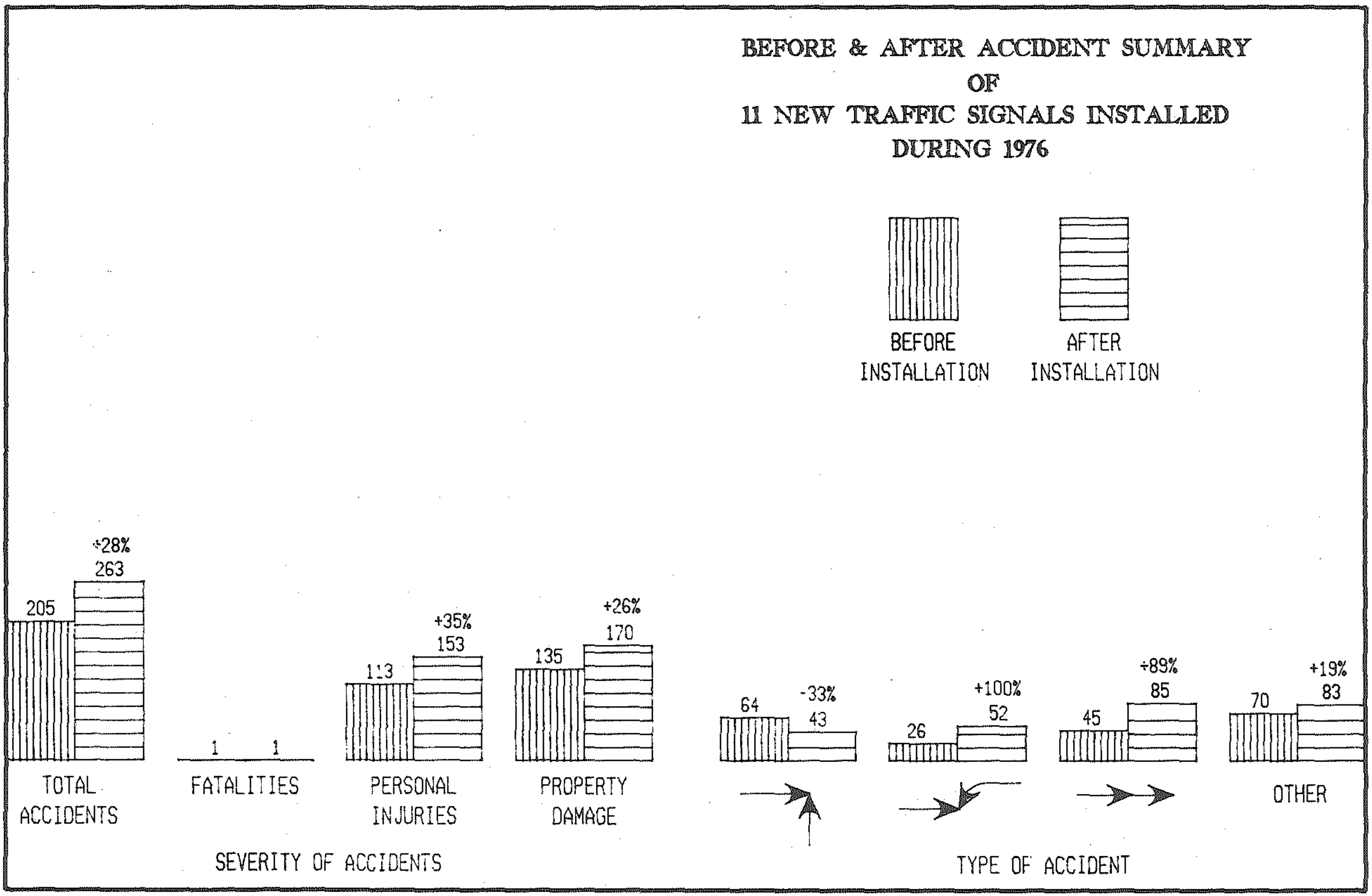

BEFORE & AFTER ACCIDENT SUMMARY
OF
11 NEW TRAFFIC SIGNALS INSTALLED
DURING 1976
BEFORE
INSTALLATION
AFTER
INSTALLATION
205
+28%
263
1
1
113
+35%
153
135
+26%
170
64
-33%
43
26
+100%
52
45
+89%
85
70
+19%
83
TOTAL
ACCIDENTS
FATALITIES
PERSONAL
INJURIES
PROPERTY
DAMAGE
OTHER
SEVERITY OF ACCIDENTS
TYPE OF ACCIDENT

FIGURE 2

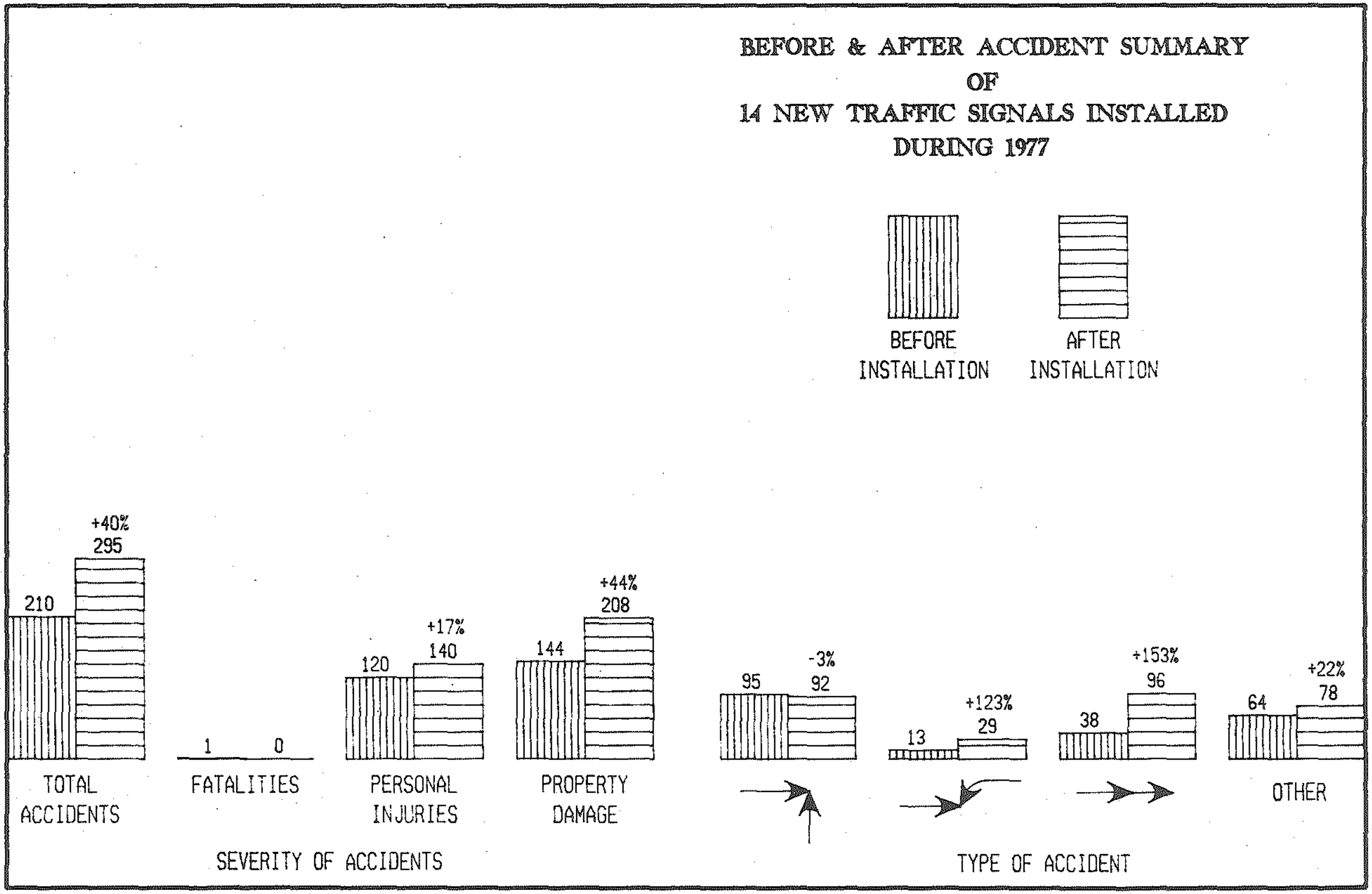

BEFORE & AFTER ACCIDENT SUMMARY
OF
14 NEW TRAFFIC SIGNALS INSTALLED
DURING 1977
BEFORE INSTALLATION
AFTER INSTALLATION
210
+40%
295
1
0
120
+17%
140
144
+44%
208
95
-3%
92
13
+123%
29
38
+153%
96
64
+22%
78
TOTAL ACCIDENTS
FATALITIES
PERSONAL INJURIES
PROPERTY DAMAGE
OTHER
SEVERITY OF ACCIDENTS
TYPE OF ACCIDENT

FIGURE 3

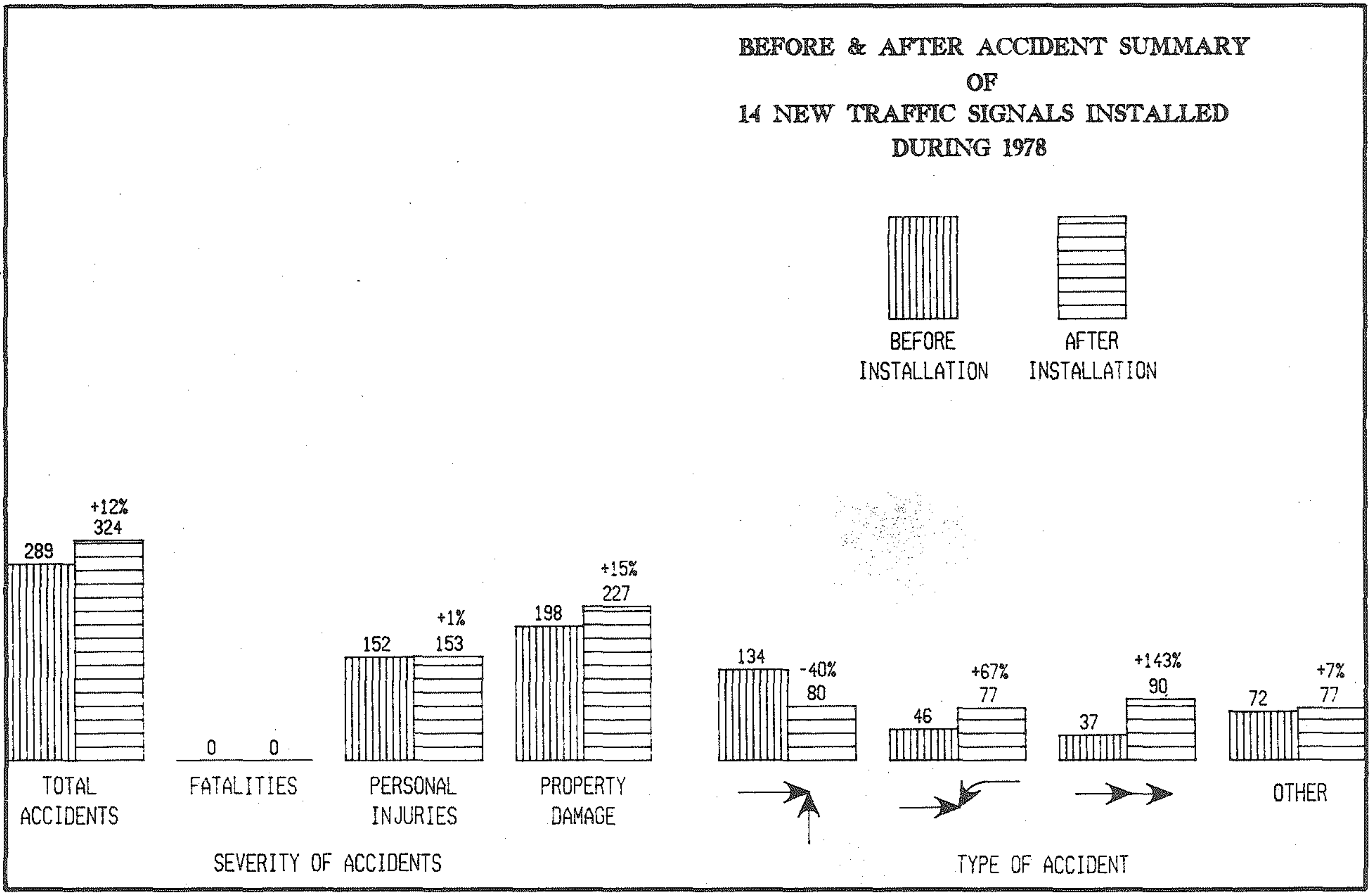

BEFORE & AFTER ACCIDENT SUMMARY
OF
14 NEW TRAFFIC SIGNALS INSTALLED
DURING 1978
BEFORE INSTALLATION
AFTER INSTALLATION
289
+12%
324
0
0
152
+1%
153
198
+15%
227
134
-40%
80
46
+67%
77
37
+143%
90
72
+7%
77
TOTAL ACCIDENTS
FATALITIES
PERSONAL INJURIES
PROPERTY DAMAGE
OTHER
SEVERITY OF ACCIDENTS
TYPE OF ACCIDENT

FIGURE 4

The before-and-after accident statistics for each year are shown individually in Figures 2 through 4 showing the types and severity of accidents. Each of the three-years show the same basic patterns of accidents due to signal installations; total, left-turn, and rear-end accidents all increased in number, right-angle accidents decreased and other accidents remained relatively stable.

When the accident records for the individual years are plotted according to accident severity, the graphs exhibit an increase in both the number of people injured and accidents involving property damage. The number of fatalities changed from two before to one after the signals were installed, not yielding any conclusion.

Discussion and Summary

The data in this report reveal that the installation of traffic signals was followed by a 25 percent increase in total accidents at the 39 newly signalized intersections studied. This increase is attributed to the new signals at the 99 percent confidence level using the Student t test. In the similar study by Max Clyde, P.E., in the early 1960's, the findings are parallel, that is, accidents increased following the installation of traffic signals. Contrary to popular belief, traffic signals are not necessarily safety devices, but a means to alternately assign right-of-way at a street intersection. Because the right-of-way assignment alternates under signal control from one approach to another, it is necessary for more drivers to make decisions, than with two-way stop control. When the signal indication is yellow, motorists are required to judge whether they can safely travel through the intersection or stop.

Popular belief presupposes that angle accidents will be eliminated because of the definite assignment of right-of-way. Right-angle accidents were, in fact, the only type of accident that decreased in number, decreasing by more than 25 percent, from 293 to 215. Left-turn accidents increased by 86 percent (99 percent level of significance). In most instances, this increase is due to poor gap selection. During peak traffic periods, the heavy through movement affords little opportunity for left-turning vehicles to utilize the short gaps that occur. Many left-turners must therefore turn during the yellow signal indication at the end of the green cycle.

Rear-end accidents more than doubled at newly signalized intersections (99.9 percent confidence level). This marked increase is expected because a significant percentage of major street traffic is being brought to a stopped condition from 40 to 60 times an hour while it was not previously required to stop at all. All other accident types (including head-ons, sideswipes, parking, fixed-object, etc.) increased 16 percent (89 percent level significance).

The combined fatalities and injuries increased 16 percent; Student's t test credits the change to the signal installations at a 94 percent confidence level. Accidents involving property damage rose 27 percent. The statistical analysis attributes the rise to signal installation at a 98 percent confidence level.

All of the statistical data is contained in the Appendix.

APPENDIX

Statistical Analysis

A widely accepted method of comparing before-and-after data is to use the Student's t test. Paired samples were used in this analysis because of the assumption that all variables remained relatively constant over the study period except for the treatment (installation of stop-and-go traffic signals) and the same parameters were compared at the same locations (accident-type and severity).

The goal of the statistical analysis is to establish whether or not the difference between two samples is significant. To accomplish this, two hypotheses are formulated. In this study, the hypotheses are:

1. Null Hypothesis (H_0): μ Before $\geq \mu$ After

   i.e., the mean number of total accidents in the "before" period is greater than or equal to the mean number of total accidents in the "after" period.

2. Alternative Hypothesis (H_1): μ Before $< \mu$ After

   i.e., the mean number of total accidents in the "before" period is less than the mean number of total accidents in the "after" period.

These hypotheses are tested at the 90 percent confidence level. Table A-1 contains the statements used for each category tested.

Hypotheses Used Table A-1

	H_0	H_1
Angle Accidents (ANGLE)	$\mu_b \geq \mu_a$	$\mu_b < \mu_a$
Left-Turn Accidents (LEFTS)	$\mu_b \geq \mu_a$	$\mu_b < \mu_a$
Rear-End Accidents (REAR)	$\mu_b \geq \mu_a$	$\mu_b < \mu_a$
Miscellaneous Accidents (OTHER)	$\mu_b \geq \mu_a$	$\mu_b < \mu_a$
Number Injured or Killed (KILLINJ)	$\mu_b \geq \mu_a$	$\mu_b < \mu_a$
Property Damage Only Accidents (PD)	$\mu_b \geq \mu_a$	$\mu_b < \mu_a$

The null hypothesis is the assumption that is being tested--it is to be either rejected or not rejected. The alternative hypothesis is the set of all possible outcomes excluding the null hypothesis. Because the mean of the "before" period was assumed to be greater than or equal to the mean of the "after" period, the one-tailed probability should be used, that is the difference between means is unidirectional.

The SPSS program employed to generate the probabilities in this report uses a two-tailed probability. To convert the two-tailed probability to the one-tailed probability that should be used, the two-tailed probability is divided by two giving the significance level. The confidence level is then determined by subtracting the value of the one-tailed probability from 1.00.

Example: The two-tailed probability for property damage accidents (BPD and APD) is 0.031, so 1.00 - (0.031)/2 = 0.9845 = 98 percent confidence level.

First, the total mean number of accidents in the "before" period was compared to the total mean number of accidents in the "after" period. If a significant difference in total accidents is found, then tests can be performed on a breakdown of the data (post hoc testing), e.g. accident type. A significant difference was found ($p = 0.10$) between the total accidents before-and-after; therefore, accident type could be tested. The number of accidents for some of the intersections was too small to assure stability. For this reason, individual intersections were not tested.

All accident types except those coded as "Other" and the combined fatalities and injuries parameter were found to be significant at the 95 percent confidence level (refer to Table C-2). Because the number of fatalities was so small, they were added to the number of injuries to formulate a new parameter KILLINJ, which was then analyzed. This new parameter was found to be significant at $p = 0.10$.

The t values of all the data were negative except the t value for angle accidents, meaning that H_0 is rejected in all cases examined except H_0 for right-angle accidents. In fact, because the t values were negative, it leads one to believe that the converse of the null hypotheses would have been better selections of major premises. Had it been assumed that accidents increase from the "before" period to the "after" period, all t values save the t value for right-angle accidents would have been positive. However, the sign of the t value has no bearing on the numerical results of the statistical analysis.

Table A-2

Number of Accidents* and Severity

Variable	Before	After	Percent Change
Total accidents	704	882	+25**
Angle Accidents	293	215	-27**
Left-Turn Accidents	85	158	+86**
Rear-End Accidents	120	271	+126**
Other Accidents	206	238	+16
Fatalities and Injuries	387	447	+16
Property Damage Accidents	477	605	+27**

*Based on data from all 39 signals over the entire study period.
**Significant ($p \leq 0.05$).

The SPSS statistical analysis for all signals under study is contained on pages C-6, including a copy of the program used and output generated.

100	76	0008	0008	003	004	000	002	001	002	004	000	0	0	0	0	000	000	002	003	008	006
200																					
300	76	22	8	13	0	1	6	3	0	5	2	0	0	0	0	10	14	2	2	12	6
400																					
500	76	30	32	23	4	0	10	1	14	6	4	0	0	0	0	8	12	9	14	22	23
600																					
700	76	21	30	9	2	2	2	6	13	4	13	0	0	0	0	5	10	6	9	16	24
800																					
900	76	21	30	3	4	2	2	8	14	8	10	0	0	0	0	5	6	13	23	16	17
1000																					
1100	76	24	54	13	23	4	16	1	7	6	8	0	0	1	1	5	6	21	42	19	32
1200																					
1300	76	6	11	2	3	0	1	3	4	1	3	0	0	0	0	1	1	2	3	5	9
1400																					
1500	76	8	21	1	4	1	2	2	6	4	9	0	0	0	0	1	1	9	11	7	12
1600																					
1700	76	23	33	7	5	1	2	1	14	14	12	1	1	0	0	8	12	11	19	14	22
1800																					
1900	76	23	29	10	2	7	7	5	13	1	7	0	0	0	0	11	23	12	19	12	17
2000																					
2100	76	19	21	6	5	1	3	7	10	5	3	0	0	0	0	9	11	10	19	10	11
2200																					
2300	76	22	35	6	2	2	13	4	9	10	11	0	0	0	0	5	11	19	35	17	16
2400																					
2500	76	31	25	13	5	4	3	6	11	8	6	0	0	0	0	12	19	9	13	19	16
2600																					
2700	76	28	1	8	0	6	0	8	0	6	1	0	0	0	0	14	24	0	0	14	1
2800																					
2900	77	18	32	4	9	4	6	3	8	7	9	0	0	0	0	5	8	7	13	13	25
3000																					
3100	77	9	16	3	5	0	4	3	4	3	3	0	0	0	0	4	9	3	6	5	13
3200																					
3300	77	14	22	12	8	0	1	1	8	1	5	0	0	0	0	7	10	10	19	7	12
3400																					
3500	77	23	34	12	11	0	6	4	14	7	3	0	0	0	0	7	16	11	17	16	23
3600																					
3700	77	5	15	2	5	1	0	1	5	1	5	0	0	0	0	0	0	1	1	5	14
3800																					
3900	77	16	29	8	4	1	1	3	11	4	13	0	0	0	0	4	7	7	12	12	22
4000																					
4100	77	29	22	3	4	1	0	4	10	21	8	0	0	0	0	6	10	5	5	23	17
4200																					
4300	77	6	18	3	11	0	1	2	1	1	5	0	0	0	0	3	5	9	14	3	9
4400																					
4500	77	25	23	19	16	2	1	2	3	2	3	0	0	0	0	5	8	8	15	20	15
4600																					
4700	77	3	10	2	4	0	0	1	5	0	1	0	0	0	0	3	6	3	5	0	7
4800																					
4900	77	8	2	4	0	1	0	0	2	3	0	0	0	0	0	4	7	0	0	4	2
5000																					
5100	77	46	1	33	0	4	0	4	1	5	0	0	0	0	0	15	24	1	1	31	0
5200																					
5300	77	20	21	7	3	2	1	7	11	4	6	1	1	0	0	5	7	6	6	14	15
5400																					
5500	77	17	52	10	10	0	17	3	21	4	4	0	0	0	0	4	5	22	38	13	30
5600																					
5700	77	5	23	0	7	0	3	1	5	4	8	0	0	0	0	1	1	4	6	4	19
5800																					
5900	77	29	28	16	5	1	5	6	9	6	9	0	0	0	0	11	26	13	21	18	15
6000																					
6100	77	18	22	10	10	1	0	4	10	3	2	0	0	0	0	6	8	10	20	12	12
6200																					

YEAR	BTOT	ATOT	BANGLE	AANGLE	BLEFTS	ALEFTS	BREAR	AREAR	BOTHER	AOTHER	BFATAL	BKILLED	AFATAL	AKILLED	BINJURY	BINJURED	AINJURY	AINJURED	BPD	APD
78	31	17	8	6	5	3	9	5	9	3	0	0	0	0		12	7	16	20	10
78	9	21	3	10	0	2	2	7	4	2	0	0	0	0	2	6	5	6	7	16
78	12	11	4	2	3	6	2	2	3	1	0	0	0	0	4	6	2	2	8	9
78	13	14	2	2	2	1	2	5	7	6	0	0	0	0	4	5	2	2	9	12
78	21	24	9	6	3	7	6	6	3	5	0	0	0	0	5	8	10	21	16	14
78	35	30	6	2	14	8	3	9	12	11	0	0	0	0	14	19	7	9	21	23
78	54	46	33	15	6	5	5	13	10	13	0	0	0	0	16	23	13	24	38	33
78	18	29	5	7	5	10	2	10	6	2	0	0	0	0	6	15	12	26	12	17
78	28	19	15	6	3	3	4	3	6	7	0	0	0	0	11	18	6	7	17	13
78	12	54	0	6	8	22	1	15	3	11	0	0	0	0	3	4	13	16	9	41
78	10	3	5	0	0	0	0	0	5	3	0	0	0	0	2	3	0	0	8	3
78	48	56	38	28	2	8	3	11	5	9	0	0	0	0	11	24	24	43	37	32
78	7	24	2	3	2	11	1	6	2	4	0	0	0	0	2	2	8	10	5	16
78	15	7	5	0	1	0	6	4	3	3	0	0	0	0	5	8	2	2	10	5
78	33	45	15	10	2	0	10	27	6	8	0	0	0	0	12	17	15	19	21	30
78	8	3	0	0	0	0	2	1	6	2	0	0	0	0	1	2	0	0	7	3
78	14	11	2	1	5	2	6	8	1	0	0	0	0	0	5	6	4	6	9	7
78	2	14	1	6	0	4	1	4	0	0	0	0	0	0	1	4	6	9	1	8
78	12	10	5	1	0	1	3	5	4	3	0	0	0	0	4	10	1	1	8	9
78	18	6	12	3	0	2	3	0	3	1	0	0	0	0	6	8	2	3	12	4
78	24	30	1	5	1	6	13	12	9	7	0	0	0	0	8	8	11	16	16	19
78	7	15	2	5	0	0	2	7	3	3	0	0	0	0	3	7	5	8	4	10
T76	286	338	117	63	31	69	56	117	82	89	1	1	1	1	94	150	125	212	191	212
T77	291	370	148	112	18	46	49	128	76	84	1	1	0	0	90	157	120	199	200	250
T78	431	489	173	124	62	101	86	160	110	104	0	0	0	0	136	215	155	246	295	334
TOT	1008	1197	438	299	111	216	191	405	268	277	2	2	1	1	320	522	400	657	686	796

FILE NONAME (CREATION DATE = 02/18/82)

T - T E S T

VARIABLE	NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	(DIFFERENCE) MEAN	STANDARD DEVIATION	STANDARD ERROR	CORR.	2-TAIL PROB.	T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
BTOT BEFORE ACCIDENT TOTAL		18.1795	11.406	1.826								
	39				-4.7692	11.939	1.912	0.570	0.000	-2.49	38	0.017
ATOT AFTER ACCIDENT TOTALS		22.9487	13.904	2.226								
BANGLE		8.7273	8.829	1.537								
	33				2.2121	6.382	1.111	0.691	0.000	1.99	32	0.055
AANGLE		6.5152	6.083	1.059								
BLEFTS		3.2381	3.064	0.669								
	21				-2.8571	5.033	1.098	0.461	0.035	-2.60	20	0.017
ALEFTS		6.0952	5.647	1.232								
BREAR		3.0286	2.022	0.342								
	35				-4.8857	3.902	0.659	0.323	0.058	-7.41	34	0.000
AREAR		7.9143	4.054	0.685								
BOTHER		5.4722	4.025	0.671								
	36				-0.8611	4.148	0.691	0.437	0.008	-1.25	35	0.221
AOTHER		6.3333	3.787	0.631								
BKILLINJ		9.4359	6.843	1.096								
	39				-2.6667	10.564	1.692	0.385	0.015	-1.58	38	0.123
AKILLINJ		12.1026	11.104	1.778								
BPD		12.8947	8.123	1.318								
	38				-2.9211	8.038	1.304	0.571	0.000	-2.24	37	0.031
APD		15.8158	9.132	1.481								