Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UM-HSRI-77-57-2		

4. Title and Subtitle	5. Report Date
Evaluation of the Michigan Trial Substitute Motor Vehicle Inspection Program	August 1977
	6. Performing Organization Code: 013971
7. Author(s) Jairus D. Flora, Terry D. Truax, Dan Tholen, Ronald L. Copp & Richard F. Corn	8. Performing Organization Report No.: UM-HSRI-77-57-2
9. Performing Organization Name and Address: Highway Safety Research Institute, University of Michigan, Ann Arbor, Michigan 48109	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address: Michigan Department of State Police, 714 S. Harrison Road, East Lansing, Michigan 48823	13. Type of Report and Period Covered: Final Report 5/75 - 8/77
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This two-year study evaluated the Michigan checklane inspection system as a trial substitute for a periodic motor vehicle inspection program. Two counties served as the test areas. One county had a simulated PMVI, while the other had a checklane inspection of 15% of the cars. Random checklanes were used in 1975 and 1976 to estimate the condition of the cars in each county, with minimum sample sizes of 2000 cars for each study group.

The rate of equipment outages was found to depend strongly on the age of the car. Charts of this relationship are presented for several safety components. After adjusting for the age of the car, no significant differences were found in comparing the previous 5% checklane program to the more intensive 15% checklane program. Cars in the simulated PMVI program proved to be a self-selecting sample of newer cars in better mechanical condition than average, making direct comparisons to the checklane population difficult. The 1975 sample of cars in the PMVI group estimated the effects of the 5% checklane inspection program; the 1976 sample of these cars estimated the effects of the simulated PMVI group, and these two samples did not differ significantly. Thus there was no evidence of differences among the PMVI, 15% checklane, or 5% checklane.

A special study in 1975 compared a moving stopping test to a wheel-pull brake inspection. The conclusion was that the MST was more stringent and easier to perform. In 1976 the repair rates for vehicles in the PMVI group were also determined for several safety components and were reported.

17. Key Words	18. Distribution Statement
Vehicle Inspection, Vehicle Surveys, Driver Interviews Brake Inspections, Adjusted Rates, Driver Surveys Weighted Least Sqrs	Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	90 + App.	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

* U. S. GOVERNMENT PRINTING OFFICE : 1973 725-504/328

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EVALUATION OF THE MICHIGAN TRIAL SUBSTITUTE VEHICLE INSPECTION PROGRAM

1. SUMMARY

How effective is the checklane vehicle inspection conducted by the State of Michigan? How effective would a checklane inspection system be that inspected on the average 15% of the state's vehicles, coupled with an increased public awareness campaign? How would such a system compare with a periodic inspection? Which procedure--a moving stopping test or a wheel pull inspection—is better for evaluating the braking system? These are some of the questions addressed by the study conducted by HSRI jointly with the MSP and OHSP during 1975 and 1976.

To qualify for federal highway funds under existing federal law, the 50 states must conduct vehicle inspection programs. Thirty-six states employ periodic motor vehicle inspection (PMVI), under which all vehicles are inspected and certified, usually annually. Michigan conducts a year-round randomized roadside inspection program. State Police teams set up temporary checklane sites at random times and locations, order approaching motorists into them, inspect and test the vehicle, and issue citations to motorists whose vehicles are found with defects. The State Police have been inspecting about 300,000 vehicles each year, or about 6% of the passenger cars registered in Michigan.

The current study attempts to answer several questions relative to the Michigan checklane inspection program:

> What is the current proportion of defective vehicles in the driving population?
>
> Among the defective vehicles, what defects are most frequent?

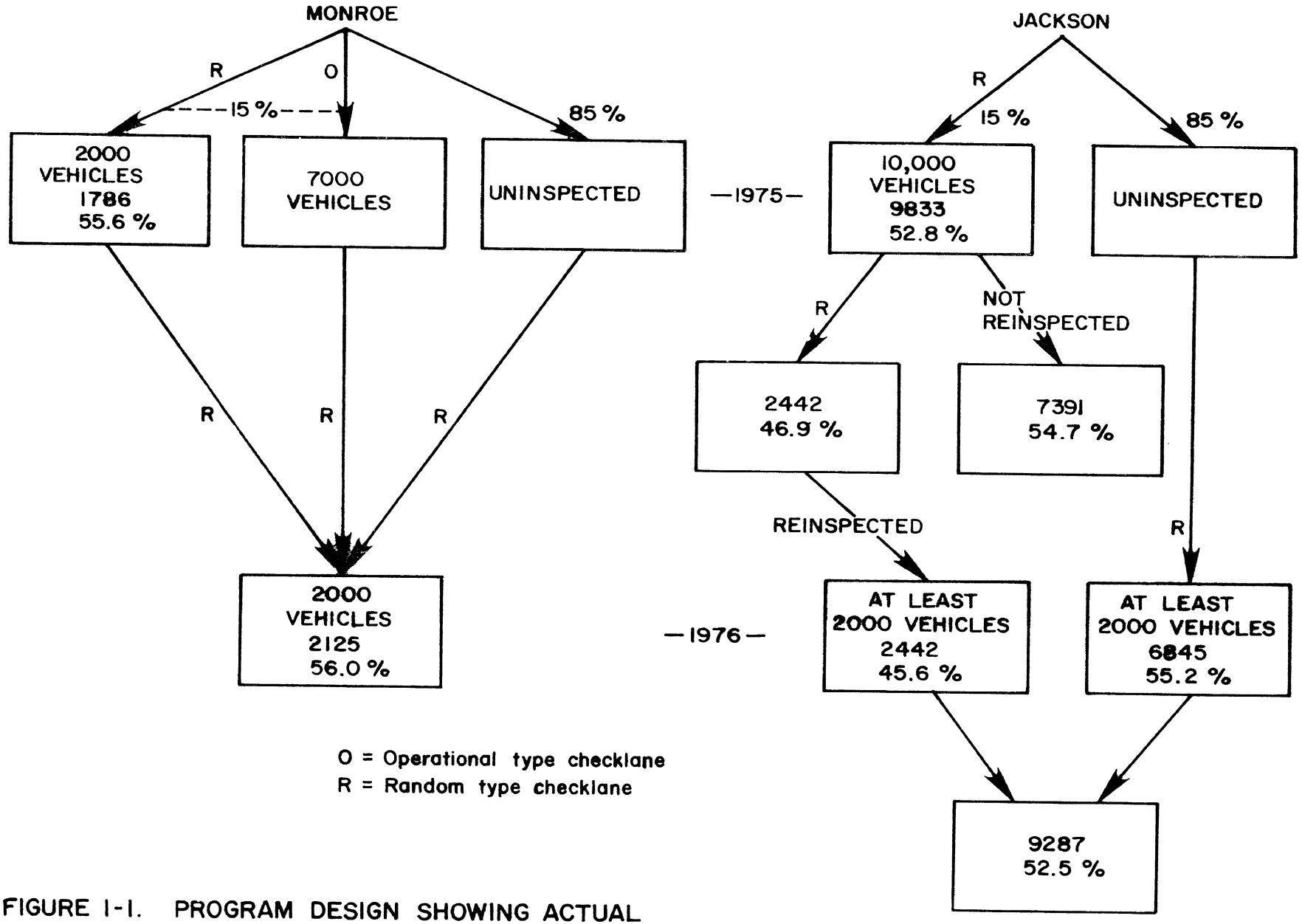

FIGURE 1-1. PROGRAM DESIGN SHOWING ACTUAL SAMPLE SIZES AND ADJUSTED FAILURE RATES.

How do two different methods for testing the braking ability of vehicles compare?

If the percent of inspected vehicles were raised to 15 percent and coupled with a public information campaign, how would the defect rate change?

How would the defect rates under a 15% inspection program compare with those for a set of vehicles which had passed an inspection the previous year?

The general plan of the study is diagrammed in Figure 1.1. Two counties were selected for the trial program, Monroe and Jackson. The two counties have a similar number of registered vehicles, and each experienced approximately a 15 percent inspection rate during 1975. Two slightly different inspection methods were employed. The inspections denoted by "R" denote random inspections in which the sites were randomly visited and, on each site, a systematic sample of vehicles with a random start was inspected. The operational inpsections, denoted by "O" in Figure 1-1, had a less rigid schedule for visiting the sites, and followed a somewhat judgmental system for selecting vehicles from the traffic flow for inspection. That is, a State Police officer would view each vehicle entering the inspection area and then order it into the inspection queue or allow it to proceed, depending on his initial impression. This results in generally a somewhat higher proportion of older vehicles actually being inspected, as well as vehicles with obvious defects, or defects suspected because of the vehicles' exterior appearance. Only the results of the random inspections were recorded for analysis.

Figure 1.1 also presents the proportion of defective vehicles in each group, adjusted for the age of the vehicle. That is, since the proportion of vehicles failing the inspection was found to increase with the age of the vehicle, and since the ages of vehicles in the different counties and different study groups were found to differ, it was necessary to remove the effect of age before comparing the proportions of defective vehicles. This was done using a direct adjust rate, and the adjusted proportions are reported in Figure 1.1. The number of vehicles actually inspected in each group is also noted on the figure.

The study plan was that Monroe County would serve as a test county for the higher level (15% of registered vehicles) of the checklane inspection, while Jackson County would serve as a test county for a simulated or pseudo-periodic inspection system. Thus, an additional sample of about 2000 vehicles during 1976 was sought from Monroe County to estimate any changes in the proportions of vehicles failing the inspection for various reasons in Monroe County. Such changes would presumably be associated with the insreased level of checklane inspections (from 5% to 15%).

In Jackson County during 1976 the following sampling scheme was used. A systematic sample with a random start was applied to all vehicles. In addition, all vehicles with a sticker on the windshield indicating that they had been inspected in 1975 were selected for inspection. Again the sites were randomly rotated as to days and hours. Thus, in Jackson County a sample of the previously (in 1975) inspected cars was obtained. In addition, a sample of the previously uninspected cars was obtained. The reinspected cars formed the pseudo-periodic inspection group, while the previously uninspected cars formed a control group. The previously inspected cars were those which had either passed the inspection in 1975 or failed it and had their defects corrected. In this sense they form a pseudo-periodic inspection group. There are some differences: the owners of the cars inspected in 1975 did not know for sure whether their cars would be inspected in 1976 or when.

The previously uninspected cars sampled in 1976 provide a control group. These are vehicles which would only be influenced by the inspection program by public information campaigns and/or word-of-mouth. As such, they do not completely represent a checklane population, since they do not include the 5% or 15% of vehicles actually inspected (and repaired if failed) that a checklane inspection program affects. In addition, since the operational checklane selects those vehicles which are most likely to fail the inspection (based on age, apparent condition,etc.), the non-inspected group may not be as good as from a checklane inspection system.

The proportion of vehicles passing the inspection in the various groups can be seen on Figure 1.1 to range from about 46% to about 56%. The

proportion passing among all the randomly inspected cars in 1975 was 50.1% and in 1976 it was 44.0%. This compares with the proportion passing the operational checklanes in Michigan during the same two years: 38.0% in 1975 and 37.0% in 1976. The passing rates are similar to those reported from areas with annual PMVI, which range from 45% to 75%.[1,2]

The proportion of cars passing the overall inspection was found to vary considerably with the age of the vehicle; older vehicles railed much more frequently. Indeed, an increasing failure rate with age of vehicle was noted for most specific components as well as for failure for any reason. The increase in proportion is approximated by a quadratic curve or parabola quite well, particularly for the latest 13 model years. The years earlier than that are based on very few cases. One interesting observation is that the failure rate is consistently over 80% for cars at least six years old, and appears to stabilize at about 90% or so for cars ten years old or older. The relationship between failure rate and age of vehicle may indicate that inspections may more profitably be concentrated in the population of older vehicles.

When one looks at the failure rate on specific vehicle components, the results are somewhat mixed. Although most components show an increasing trend in the failure rate with the age of the vehicle, some components have quite low failure rates and show little if any increase with age. These include horn, steering, mirrors, and vision-impaired windshields. On the other hand, several components--brakes, windshield washers and wipers, tires, lights, and exhaust--show marked increasing trends with age. The implications of these idfferences are not clear. They may indicate that most owners maintain those components that they perceive as essential to safe operation of the vehicle, while being more lax about maintaining the others. If this is the case, additional education about the danger of defects of particular components might be useful.

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[1] "Report of an Evaluation of Motor Vehicle Inspection," Coverdale and Colpitts, Consulting Engineers, 100 Wall Street, N.Y., April 1967, p. 5-6.

[2] "The Influence of Periodic Motor Vehicle Inspection on Mechanical Condition," R.W. McCutcheon and H.W. Sherman, HSRI, The University of Michigan, July, 1968, p.9.

Figure 1.2 illustrates the inspection results for cars in Monroe County. This provides a comparison of the 5% and 15% checklane inspection rates. The figure relates the proportion of cars which had one or more defects to the age of the vehicle. As can be observed in the figure the failure rates are quite similar. A test of significance to test whether the two curves are different failed to reject even at the 20% level. A similar comparison is provided by the failure rates adjusted for the age of the vehicle. For the 1975 data the adjusted failure rate was 55.6%, while in 1976 the rate was 56%. Clearly little change has occurred. As a result, there is no evidence to indicate that the 15% checklane inspection rate is any better than the 5% inspection rate at lowering the number of cars which fail the inspection.

Similar comparisons for each safety component showed the same general finding. That is, no differences were observed in the failure rates. One exception to this was the tires. In 1976 significantly more vehicles failed because of insufficient tire tread than failed in 1975. This difference persisted even after adjustments for age and mileage of vehicles were made. In 1975, 12% of the cars in Monroe County had insufficient tread; in 1976, 22% did. Adjusting these numbers to make the ages of the cars comparable results in the adjusted rates of 14% for 1975 and 21% for 1976--still a large difference. The reason for the difference is not known. It is possible that a more stringent inspection of the tires in 1976 was responsible for the difference.

Figure 1.3 illustrates the results for the vehicles which were inspected both in 1975 and 1976 in Jackson County.

This group was subject to the 5% checklane inspection prior to 1975, so the 1975 inspections represent the checklane population. In 1976, at the time of the reinspection, the group represents a simulated PMVI. Again, only slight differences are noted in the two curves. The differences are not statistically significant. As a summary comparison, the age-adjusted rates for the groups are 46.9% failures in 1975 and 45.6% failures in 1976. There is a slight reduction, but it is not statistically significant even at the 20% level. Thus, there is no evidence that the PMVI--as simulated by this experiment--is better than the 5% checklane inspection system.

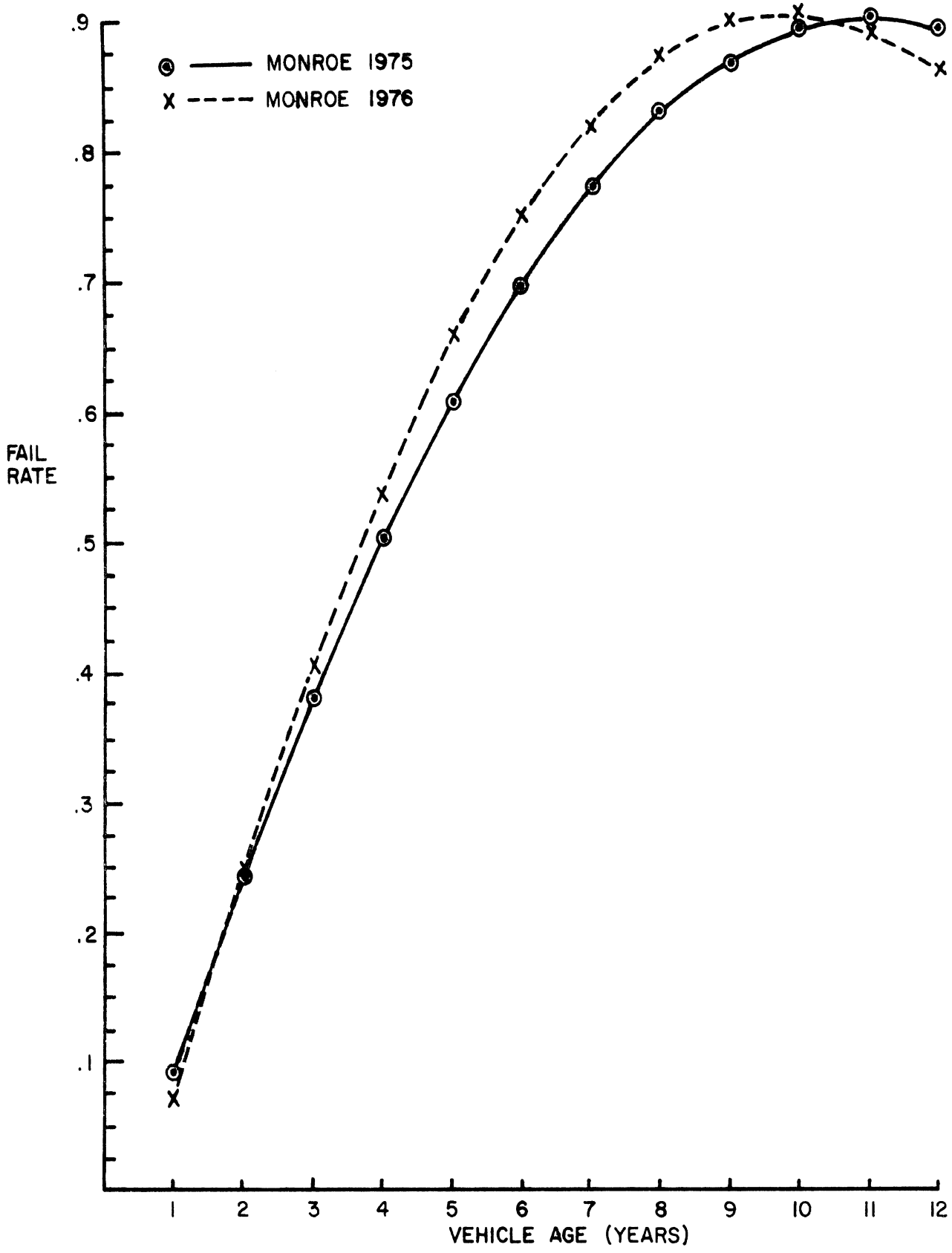

Figure 1-2 FITTED REGRESSIONS FOR FAILURE RATES BY VEHICLE AGE FOR THE 1975 AND 1976 MONROE COUNTY INSPECTIONS

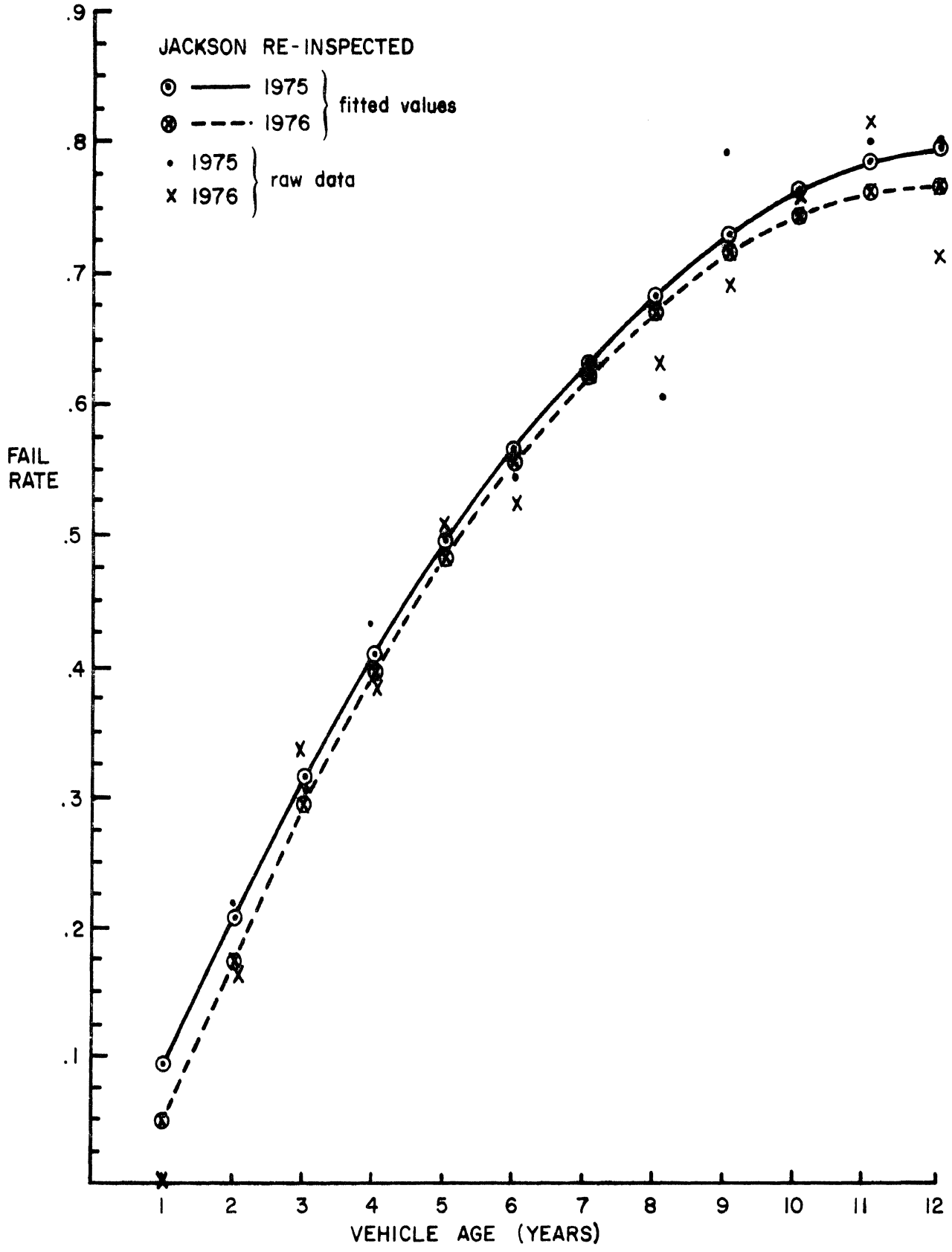

FIGURE 1-3. FITTED REGRESSIONS FOR FAILURE RATES BY VEHICLE AGE FOR THE 1975 AND 1976 JACKSON COUNTY INSPECTIONS.

Figure 1.1 gives the failure rates, adjusted for age of car, for each of the groups. It should be noted that direct comparisons between the two counties in 1976 are not appropriate. The reason for this is that the reinspected cars turned out to be a self-selecting sample. That is, the vehicles which were inspected both years were a special subgroups of the vehicles. This subgroup proved to be vehicles in better condition in 1975. This was not anticipated in the study design and could not be detected until the analysis of the second years' data was begun.

An additional comparison can be made among the vehicles in Jackson County which were newly inspected each year. This group represents the set of cars which would only be influenced by the information campaign and the knowledge that some cars were being inspected in the checklanes. That is, this group represents the "spillover" effect of a checklane. None of these cars was previously inspected and required to correct any defects. The age-adjusted rates of inspection failure for newly inspected vehicles in Jackson County in 1975 was 54.7%. In 1976 it was 55.2%. Again the difference is not statistically significant and is of no practical importance.

Table 1-1 presents failure rates by safety component for the various study groups and for both years of the inspection. One should recall that the reinspected cars are one year older in 1976, so that somewhat higher failure rates are to be expected. Also, the newly inspected cars averaged nearly one year older in 1976 than in 1975, so that one would expect slightly higher failure rates in those groups too. The one component which showed a marked increase in failures in 1976 was the tires.

Table 1-2 summarizes the failure rates by more detailed components. Cars reported in this table are grouped by the two counties rather than by study groups. This table presents the components which caused a car to fail the inspection so that one can determine which components are the most frequent cause of failure. These data represent samples from the two counties. The most frequent cause of failure is some light outage--license plate light, headlight, directional signals, tail lights, stop lights, in order. The next most common problem was a vision defect, usually

Table 1-1

GROUP FAILURE RATES BY COMPONENT (%)

Component	Group: Re-inspected Cars-Jackson Co. 1975	Re-inspected Cars-Jackson Co. 1976	Newly Inspected Cars-Jackson Co. 1975	Newly Inspected Cars-Jackson Co. 1976	Newly Inspected Cars-Monroe Co. 1975	Newly Inspected Cars-Monroe Co. 1976
Wipers & Washers	12.4	11.8	17.6	20.1	21.4	24.2
Headlights	6.8	8.4	9.2	11.8	7.3	11.6
All Lights	25.3	28.3	32.6	40.0	31.1	38.4
Brakes	5.2	6.0	10.2	12.9	12.7	15.4
Tires	8.0	14.4	12.0	18.8	12.3	22.2

Table 1-2

FAILURE RATES BY COMPONENT (%)

Component	Monroe		Jackson		Total	
	1975	1976	1975	1976	1975	1976
Vision	23.8	28.8	21.1	22.3	21.5	23.5
Front Dir.	5.4	5.4	4.9	5.7	5.0	5.6
Rear Dir.	7.2	6.2	6.9	7.6	6.9	7.3
Headlights	7.3	11.6	9.2	11.0	8.9	11.1
Stop lights	6.4	7.2	7.4	8.2	7.2	8.0
Total lights	31.1	38.4	32.5	37.0	32.3	37.2
Steering	.1	.4	.4	.3	.3	.3
Horn	3.4	4.6	3.0	3.6	3.0	3.8
Tires	12.3	22.2	12.0	17.6	12.0	18.5
Exhaust	10.1	16.7	9.3	16.7	9.4	16.7
Brakes (static)	12.7	15.4	10.2	11.2	10.6	12.0
MST (fail to stop)					.9	.3

Table 1-3

Passing Rates for Reinspected Vehicles by Number of Defects in 1975

# def. in 75	Post card Ret. Rate	% Passing in 76
0	NA	67.6
1	57.7%	43.6
2	54.1	30.2
3	49.2	20.3
4+	41.4	17.2

inadequate wipers or washers. Often the problem was caused by lack of fluid in the washer. Following these come tires--usually inadequate tread--and exhaust--usually excessive noise. A fairly large number of cars failed some portion of the brake test, but less than one percent actually could not stop in the required distance.

Cars which failed the inspection in 1975 were given a post card to sign and return certifying that they had repaired the outage. The set of cars which were reinspected in 1976 provides a check on the effectiveness of this effort. Table 1-3 gives the percents of drivers returning the post cards by the number of defects found in their cars as well as the percent of the cars which passed the inspection in 1976. In general, both the post card return rate and the percent passing the inspection in 1976 show a decreasing trend as the number of defects increases. The rate of passing in 1976 is considerably below the rate of return of the post cards. However, since nearly one-third of the cars which passed in 1975 did not pass in 1976, many of the failures may have been for different components in 1976 than in 1975. Table 1-4 gives the percent of cars passing both years, the percent of new failures in 1976, the percent of cars which passed in 1976, having failed in 1975, and the estimated repair rates. Most of the estimated repair rates are above 80% for single components. Two notable exceptions are the license plate light (64.8%), and the exhaust (56.2%). Possibly the license plate light is viewed as too minor to bother with by most people. The exhaust--which is usually too noisy--may not be fixed because it is expensive, or because the owner deliberately wants a loud exhaust. At any rate, the high repair rates for single components indicate that the check-lane inspection system was fairly successful in obtaining repair of defective equipment. At least this is true among those vehicles which were captured for reinspection the second year. The estimated repair rates are higher than the post card return rates, indicating that some of the drivers fixed the car, but neglected to return the post card.

One special question investigated by the random checklanes during 1975 was the relative performance of a moving-stopping test compared to an inspection of the brakes, including removal of a wheel for a mechanical

Table 1-4

Repair and New Failure Rates for Reinspected Vehicles

Component	Percent Passing Both Years	P [fail '76 | Pass '75] % New Failures in '76	P [pass '76 | fail '75] % State Convicted in '76	Estimated Repair Rate
Washers	81.8	8.9	79.4	87.2
Wipers	78.8	10.1	76.2	84.8
Front Turns	94.2	3.2	88.1	91.0
Rear Turns	91.4	4.6	78.6	82.4
Headlights	86.6	7.2	74.5	80.3
High Beam	88.9	6.2	76.6	81.7
Tail Lights	91.2	4.6	71.3	74.7
Stop Lights	90.3	4.3	74.8	78.2
License Plates	79.3	9.0	59.0	64.8
Tire Tread	80.0	13.1	71.5	82.3
Parking Brake	90.9	4.3	68.0	75.3
Stop	90.8	3.9	90.9	94.6
Pull to Side	96.0	3.3	87.6	90.6
Combined	81.8	7.7	83.3	90.2
Exhaust	86.6	8.4	51.5	56.2
All Lights	59.7	20.0	47.5	59.4
Major Mechanical	49.3	28.6	39.6	55.5
Total Inspection	41.6	32.4	34.5	51.0

inspection of the braking system. The moving-stopping test was conducted as follows. The vehicle was turned over to a regular state police trooper. The trooper accelerated the vehicle to twenty miles per hour, and attempted to stop in a lane twenty-five feet long and ten feet wide. A vehicle was judged to fail if it failed to stop, pulled to either side, if there was an unusual sound from the brakes, or if the pedal pressure required to stop was not within safe bounds.

A random subset of the vehicles in the random checklane were also given the "wheel-pull" brake inspection. In this inspection the right front wheel of the vehicle was removed to permit inspection of the condition of the brakes. A vehicle was judged to fail this inspection if any of the following conditions were found: lining on the brake shoe or pad less than 1/32 inch, cracked rotor or drum, defective or leaking wheel cylinder, low master cylinder fluid level. This inspection was conducted independently and without knowledge of the results of the stopping test.

A total of 2465 vehicles were given both types of brake inspections/ stopping tests in the two counties combined. The results are shown in Table 1-5. The two testing procedures agreed on 75.0% of the vehicles. There were 617 cases of disagreement as to pass or fail between the two methods. If the disagreements were symmetric--that is, if a vehicle was equally likely to pass the wheel pull and fail the stopping test as it was to pass the stopping test and fail the wheel pull--then approximately equal numbers of each type of disagreement would be expected. In fact, the numbers are quite unequal and the difference is statistically significant beyond the .001 level by McNemar's test.

Table 1-5

Comparison of Braking Test Results

		Wheel Pull Inspection		
		Pass	Fail	Total
Moving Stopping Test	Pass	1773	114	1887
	Fail	503	75	578
	Total	2276	189	2465

The disagreements in the two methods of evaluating the braking system of the vehicle raise the policy question of which method should be preferred. The moving-stopping test requires less equipment and is cheaper and faster to conduct than the wheel-pull inspection. It also does not require the presence of one or more mechanics. On the other hand, the wheel-pull inspection provides a more definitive statement of the mechanical condition of the braking system--at least of the right front wheel. This might indicate vehicles which currently could stop, but which might need repairs to the brakes in the near future.

One useful comparison of the results of the two tests is to assume that vehicles which failed either test are deficient in braking capability. One can then estimate what proportion of the vehicles passed by either criterion would actually be defective. Formally this is the conditional probability that a vehicle which passes the moving-stopping test actually has defective brakes (as judged by the wheel pull). The similar quantity is the conditional probability that a vehicle which passes the wheel-pull inspection actually is deficient in stopping capability (as judged by the moving stopping test).

From Table 1-5 the estimate of the proportion of vehicles which would pass the moving stopping test but yet have defective brakes is found to be $\frac{114}{1887} = 0.060$. A 95% confidence interval for this proportion is from 0.043 to 0.077.

On the other hand, the estimate of the vehicles which would be deficient in stopping capability, given that they passed the wheel pull inspection, is $\frac{503}{2276} = 0.221$. A 95% confidence interval for this proportion is from 0.200 to 0.242.

The comparison of the two proportions in the preceding paragraphs may be viewed as comparing the expected proportions of vehicles with defective stopping capabilities which would not be detected if only one of the two brake inspection techniques were used. Thus, if only the wheel-pull inspection were used, one might expect over 20% of the vehicles which passed the inspection to be deficient in stopping capability. On the other hand, if only the moving stopping test were used, one would expect only about 6% of the vehicles which passed to actually have deficient braking capability.

This comparison, coupled with the ease and economy of performing the moving-stopping test, would seem to argue that it is the superior test procedure.

Note that only one wheel was inspected in the wheel pull inspection. Presumably more vehicles with deficient braking systems would be detected if two or more wheels were to be inspected. However, this would markedly increase the difficulty and cost of performing the wheel-pull inspection. Also, the usual practice is to reline brakes on all four wheels at the same time, so the condition of one brake is generally regarded as a good indicator of the others. It seems doubtful that one wheel would be in much better condition than the others, though brakes are sometimes repaired in pairs (i.e., both front or both back wheels). Thus it seems unlikely that even if the wheel-pull inspection were to be extended to more wheels, a much better rate of detection of vehicles with deficient braking capability would be obtained.

Driver interviews were conducted for the subsample of vehicles selected for the wheel-pull inspection. This population of drivers was selected to represent local traffic rather than long trip and interstate traffic, so responses may not represent the population of drivers. Drivers in Jackson County demonstrated a greater knowledge of the vehicle inspection program in Michigan than did drivers in Monroe County. Jackson County drivers gave 32% more correct responses to questions dealing with knowledge of the check-lane. This seems to have been due to the more intensive media campaign in Jackson County, since 75% of the drivers there learned of the program through the media as compared with only 52% in Monroe County.

In both counties, over two-thirds of the drivers agreed that "seat belts save lives." However, officers observed only eleven percent of the drivers actually wearing them (in 1975). Reported use of seat belts was higher in Jackson County than in Monroe County. Twenty-one percent of the drivers in Jackson County reported they "always" wore seat belts and twenty-seven percent that they "often" wore seat belts. The corresponding figures for Monroe County were 17 percent and 22 percent. Jackson County drivers reported less inconvenience from seat belts (43% not inconvenienced) than did Monroe County drivers (34% not inconvenienced).

The proportion of drivers observed to be wearing safety belts increased in the 1976 inspections. In Monroe County 21.6% of drivers were wearing their safety belts at the time of the inspection. In Jackson County 34% wore safety belts. Combined, 31.7% of the drivers wore safety belts in 1976 compared with only 11% in 1975. The reasons for this increase are unknown. The most likely explanation is that, while some increase occurred, belt wearing was underreported in 1975. This may have occurred because drivers removed belts in order to reach their operators licenses before the trooper observed the belt wearing.

A large proportion of drivers (84% in Monroe, 91% in Jackson) agreed that the 55 mph speed limit reduced traffic fatalities. Slightly fewer (76% in Monroe; 74% in Jackson) agreed that higher limits should not be reinstated on all state highways. Over half of the drivers (58% and 60% in Monroe and Jackson) were also opposed to reinstating a higher speed limit only on interstates. A majority (56% in Monroe, 53% in Jackson) of the drivers interviewed felt that points should be given on a drivers license for speeding violations between 55 and 70 mph.

At the end of this year the data should provide a good estimate of the percent of vehicles in acceptable condition to be obtained by a 15% operational checklane inspection rate coupled with a public information campaign. Also, the comparison between the operational checklane inspection populations and the simulated PMVI population will provide additional evidence about the possible benefits of a PMVI in Michigan. This evidence can be coupled with estimates of the relative costs of the two inspection systems to aid administrators and the legislature in selecting the most cost-beneficial system for Michigan.

2. PROJECT DESIGN

2.1 Introduction

A roadside checklane motor vehicle inspection program has operated in Michigan since 1967. The inspection includes a vehicle check for safety related mechanical lighting and visual defects as well as a driver's license and vehicle registration check. The checklane inspection has served to satisfy the National Highway Traffic Safety Act requirement for a periodic motor vehicle inspection (PMVI) program or for an adequate substitute program.

But two questions persist: (1) what constitutes an adequate substitute program and (2) what is the comparative effectiveness of the PMVI vs. checklane programs for reducing vehicle defects? Another related question concerns the cost effectiveness of any vehicle inspection program. The checklane program is much less expensive than the PMVI program for the taxpayers. If the checklane program was as effective or nearly as effective as the PMVI program in reducing defective vehicles on the road, then the checklane program would be more cost effective. The issue of cost effectiveness is an important one since several studies[1] have shown that not more than 6% of all accidents have definite vehicle defect involvement. Data from the Michigan Department of State Police[2] indicate that only 1.25% to 1.5% of accidents in Michigan are directly due to defective equipment. Thus the cost of a vehicle inspection program must be kept within tight bounds if the vehicle inspection program is to remain cost effective.

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[1] Study to Determine the Relationshiop Between Vehicle Defects and Failures,and Vehicle Crashes, May, 1973. Indiana University Institute for Research in Public Safety.

A Tri-Level Study of the Causes of Traffic Accidents. August, 1976. Indiana University Institute for Research in Public Safety.

[2] Michigan Traffic Accident Facts, 1976. Department of State Police.

The Highway Safety Research Institute, the Office of Highway Safety Planning, and the Michigan State Police have cooperated on several studies to measure the effectiveness of the checklane inspection program.

The first effort began in 1968 and was conducted as a pilot effort to gain experience in field evaluations. No formal report was published. In 1972, a new study was begun which included two major elements:

(1) The fraction of the vehicle population inspected was experimentally at 5%, 10% and 20% controlled in three different counties of the state in order to determine the most desirable inspection level.

(2) Follow-up procedures were instituted to insure that vehicles found defective were repaired.

The inspections lasted seven months. The follow-up procedures resulted in the repair of 70% to 80% of the failed vehicles as reported by the owners. The comparisons of the different inspection rates, however, were inconclusive. The 20% inspection level did appear to produce a slight but significant decrease over time in the average number of major mechanical and visual defects per car.

The current study began in early 1975 to more carefully investigate the effects of different inspection systems on the safety condition of the Michigan motor vehicle population. Two major questions were considered. (1) Would a 15% inspection rate be more effective than a 5% rate in reducing vehicle safety inspection failure rates? (2) How does the checklane system compare with a periodic inspection for reducing safety inspection failure rates?

In addition the study addressed several other important issues. (1) Whas is the current proportion of defective vehicles in the driving population? (2) Among the defective vehicles, what defects are most frequent? (3) Which procedure, a moving stopping test or a wheel pull inspection is better for evaluating the braking system?

Some information on the knowledge and opinions of the drivers was also collected.

2.2 Experimental Design

At least two years were needed for the project: the first year to implement the programs and the second year to measure the effects. That is, only baseline descriptions of the vehicle populations were collected the first year. Comparisons of the programs and conclusions about the effects could not be made until the second year's data were collected and analyzed.

Two similar counties in Michigan, Monroe County and Jackson County, were selected as the study areas. Most counties (all but two previous experimental counties, Ingham and Genesee) in Michigan were being inspected by operational checklanes at a 5% level during the previous inspection years. Monroe County was selected for the more intense 15% inspection procedure for the year 1975. Before the operational checklane began the 15% inspection procedure, a special checklane was operated to obtain a random sample of about 2000 vehicles. (The difference between the random and operational checklanes is described later in this section). This random sample taken from Monroe County had two purposes: (1) to determine the baseline state of the vehicles in Monroe County previously subjected to the 5% checklane vehicle inspection program and (2) to provide a profile of the vehicle population in Monroe County for comparisons with Jackson County. A second random sample of about 2000 vehicles was obtained during the second year (1976). This second random sample measured the effect of the 15% checklane inspection program. Thus, at the end of the second year, a measure of the effect of the more intense 15% checklane inspection program was obtained by comparing the random sample taken during the first year (1975) with that taken in 1976 after the 15% checklane had been in operation for one year.

Due to legislative requirements, it was not possible to have an actual periodic motor vehicle inspection program operate. Consequently, an attempt was made to simulate such a PMVI as closely as possible within the framework of the enabling legislation. In Jackson County, a random sample of 10,408 vehicles was

inspected by the random checklane inspection teams. This comprised approximately 15% of the registered vehicles in the County. These vehicles had a sticker placed on their windshields so that they could be identified in the subsequent year. The owners were requested to correct any defects found and were told that they were not subject to the operational checklane inspections the remainder of the year, but that their vehicles could be re-inspected the following year. The group which is re-inspected would thus simulate a population of PMVI vehicles with one year's experience in 1976.

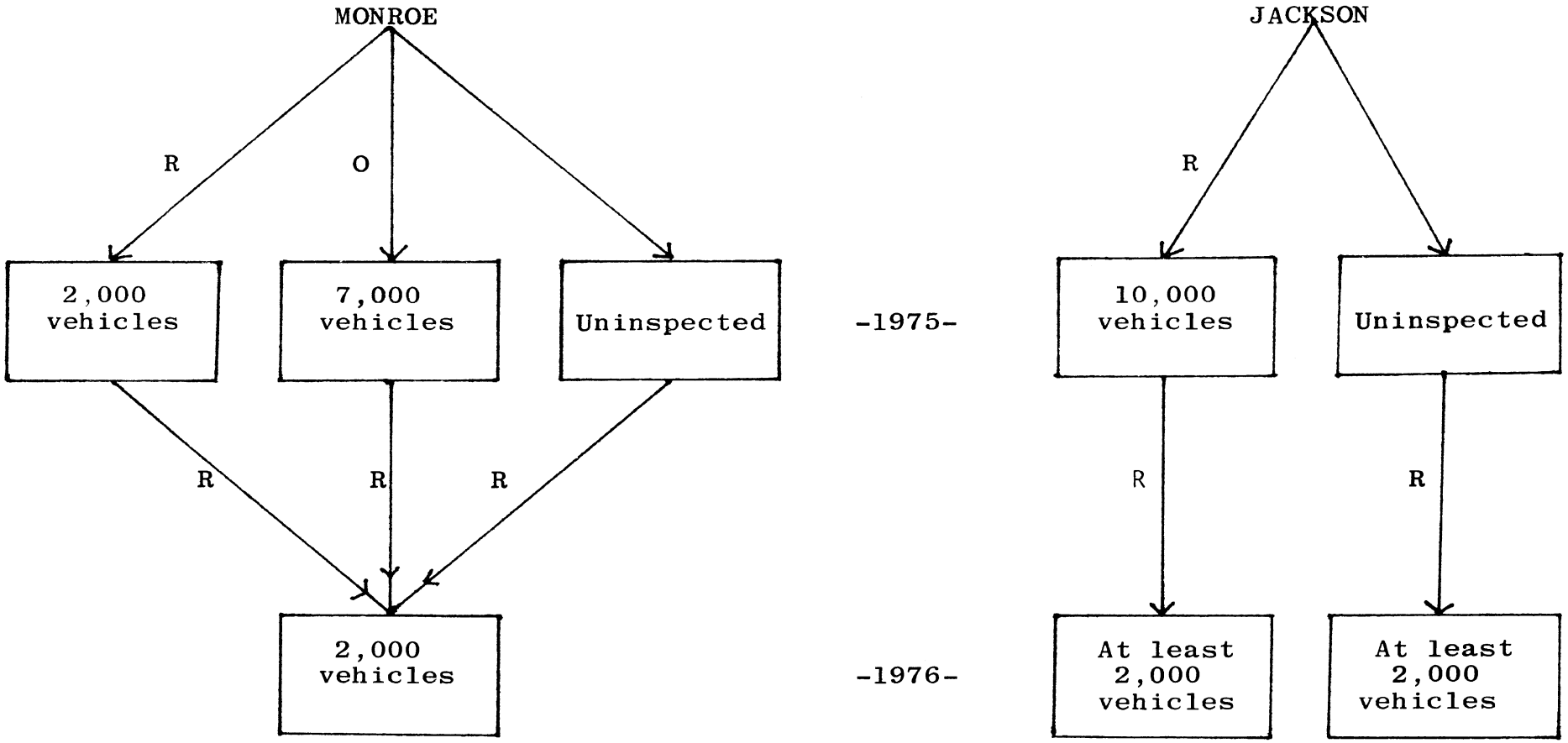
As discussed above, during 1976, a second random sample of about 2000 vehicles was taken from Monroe County to measure the effect of the 15% checklane inspection program. In Jackson County, a random sample of about 2000 vehicles was taken from the previously inspected vehicles to measure the effect of the simulated PMVI program. In addition, a random sample of about 7000 was obtained from the population of uninspected vehicles in Jackson County.

The random sample from the previously inspected vehicles in Jackson County was used to measure the effect of the (simulated) PMVI by comparing its results to the original sample of vehicles from Jackson County. If the vehicle populations of the two counties are sufficiently similar, a direct comparison of the checklane program and the PMVI program can be made on the basis of the comparison of two random samples: that from the general vehicle population of Monroe County in 1976 and that from the previously inspected vehicles in Jackson County.

If important differences in the two counties are found which affect defect rates, and if these cannot be adjusted for, then an alternative comparison of the PMVI program with the checklane program is possible using only the 1976 samples from Jackson County. The sample from the previously inspected cars would represent a sample from a PMVI population, while the sample from the previously uninspected population would represent a sample from a

FIGURE 2.1

PROGRAM DESIGN



O = Operational type checklane
R = Random type checklane

population which had been subject to a 15% checklane inspection, but which had not actually been inspected. This comparison is biased in favor of the PMVI group, since one of the benefits of the checklane is presumeably to effect repair of those vehicles stopped and found defective. However, this comparison would provide an upper bound on the benefits of the PMVI over the checklane. The bias could be removed by randomly selecting a subsample (of size equal to 15% of the sample size of the uninspected sample--about 300) and combining these with the uninspected sample to obtain a random sample of a population which was subjected to a 15% random inspection program, but which does not have the 15% of the vehicles which were previously inspected artificially removed.

Figure 2.1 summarizes the design of the study. In the figure, "R" denotes the random sample of vehicles inspected by the random checklane, while "O" denotes vehicles inspected by the operational checklane as usually operated by the Michigan State Police. There are some differences between the operational and the random checklanes. The operational checklanes were not restricted to a set pattern of sites. In addition, the officers could use their judgment in selecting vehicles for inspection from the traffic stream. Thus, they could tend to select older vehicles, vehicles with obvious defects, or vehicles suspected of defects because of the vehicle's exterior appearance, etc. The random checklane team adhered strictly to a random sampling protocol for visiting the inspection sites and for selecting the vehicles from the traffic stream for inspection. A vehicle with a flagrant defect would be stopped, however, but not included in the sample data unless it met the sampling protocol. Also, the random checklane inspection team conducted a moving stopping test and various interviews which were not part of the operational checklane procedure.

2.3 Field Operations

2.3.1 The Sample Checklane Procedures. The sample checklane inspections were conducted in cooperation between the Michigan State Police and the HSRI researchers. The Michigan State Police performed most of the inspection, while the HSRI researchers were involved only in the driver interviews and the wheel pull inspections which were only conducted during the first year.

The checklane inspection takes place adjacent to a roadway. A diagram of a typical inspection lane is given in Figure 2.2. Vehicles are directed out of the traffic stream, are inspected for defects in major systems, are given a moving stopping test, and then released, given a postcard to return (for minor defects), or issued a summons (for major defects). A subsample is selected for driver interviews and for a brake inspection involving removal of one wheel to permit inspection of brake components.

The point man is responsible for selecting the vehicles from the traffic stream for the inspection. In the random checklane, he began each period with a random start, after which he selected every n-th eligible vehicle into the inspection lane. (Eligible vehicles were passenger cars and light trucks with Michigan license plates.) Thus, the random checklane used a systematic sample of vehicles with a random start. The interval, n, varied, depending upon the density of traffic flow at the site. Since higher sampling rates could be used at sites with low traffic volume, high density sites were visited more frequently to balance the density. Hence, over the course of the sample, approximately equal fractions were sampled from high density and low density sites.

Once the vehicle was selected for inspection, it was directed to the inspection area, where a regular trooper or a service trooper would inspect the vehicle systems. The results of the inspection were recorded on a computer mark-sense form, sample of which is given in Appendix A.1. The service troopers also checked

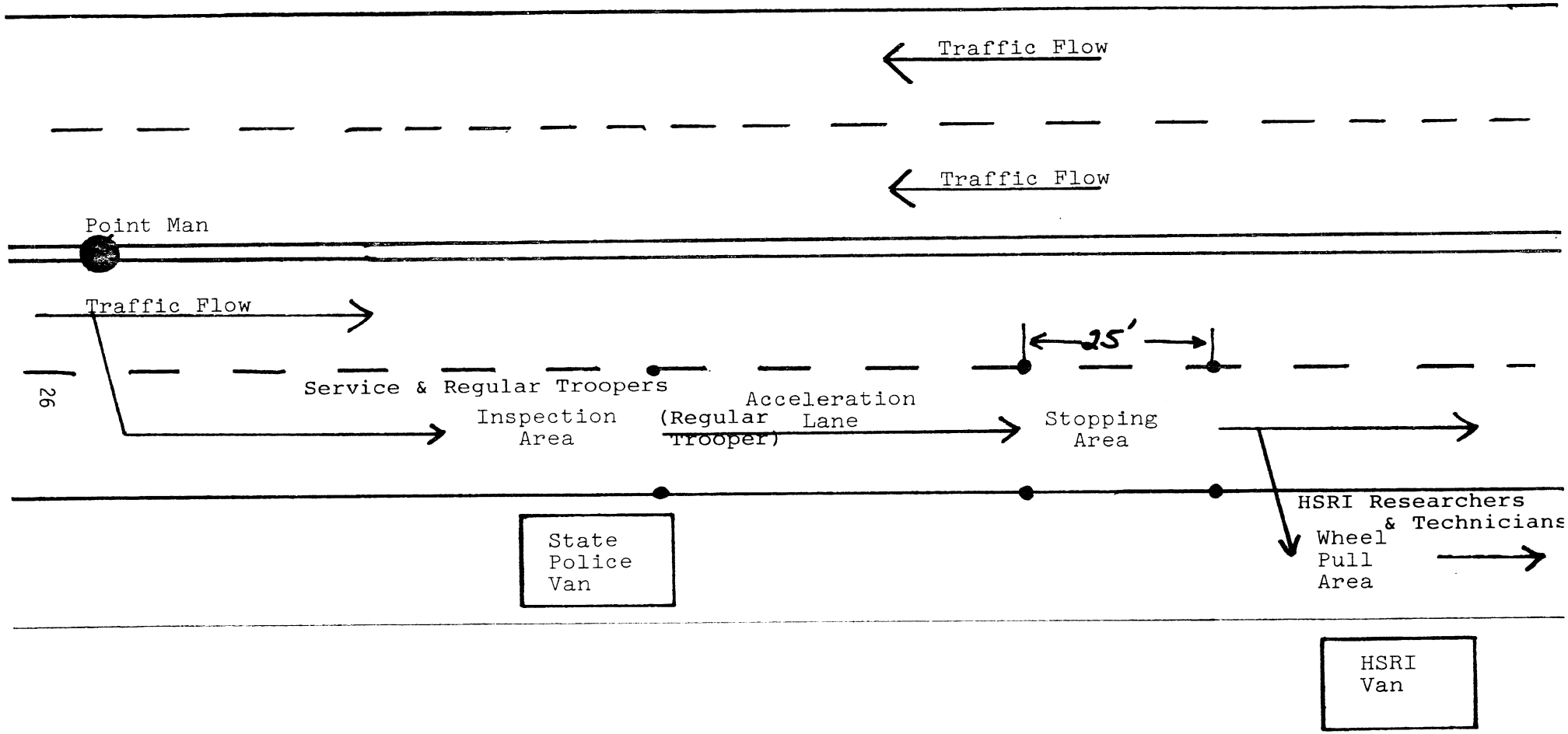


Figure 2.2

TYPICAL INSPECTION LANE

the driver's license, vehicle registration, and vehicle insurance, and issued a postcard to the driver if any inoperative equipment was found on the vehicle. In Jackson County, a prenumbered sticker was placed on the lower left corner of the windshield. This sticker exempted the vehicle from further inspections during the year and provided the means of identification for the second year's sample.

After the visual inspection of the vehicle had been completed, it was turned over to a regular trooper who conducted the moving stopping test. The trooper entered the vehicle, accelerated to twenty miles per hour, and then attempted to stop in a lane twenty-five feet long and ten feet wide. The results of this test were recorded on unused lines at the end of the mark-sense form and were tabulated along with the other results.

During the first year of the study, after the moving stopping test was completed, the vehicle was directed to the wheel-pull area for a driver interview and a mechanical inspection of brake components by HSRI technicians if that area was free. If the wheel pull area was occupied, the vehicle was released if it has passed. If major safety defects had been found, the vehicle was detained and a summons written. If minor defects were found the driver was instructed to repair these and return the postcard certifying that the defects had been repaired, after which the vehicle was released. A sample of the postcard form is given in Appendix A.2.

2.3.2 The Operational Checklane Procedures. The operational checklane procedure differed slightly from the random checklane. In the operational checklanes, no moving stopping tests or wheel-pull brake inspections were conducted, nor were any driver interviews

taken. Also, no postcards were issued. Drivers were either issued a summons for major defects, or were verbally instructed to repair any minor defects found. The other major difference is in the selection of vehicles for inspection.

In the operational checklanes, sites were visited on a judgmental basis rather than according to a prescribed sampling schedule. Further, the selection of vehicles from the traffic stream for inspection is left to the judgment of the point man. He may select a higher proportion of older vehicles or those which appear to be likely to have defects from the general appearance. In consequence, operational checklanes may be more efficient at finding defective vehicles than random checklanes. However, the random selection process is necessary to accurately reflect the status of the vehicle population.

Because no moving stopping tests or wheel-pull inspections of brakes were conducted in the operational checklanes, the site requirements for an operational checklane are not as stringent as those for a sample checklane. Consequently a wider variety of roadways may be used with a correspondingly better coverage of the vehicle population.

2.3.3 Site Requirements. The procedure for conducting checklane inspections dictated certain requirements for the inspections sites. A prospective site had to have ample room for vehicles to wait without blocking traffic while undergoing the inspection and space for the police van to be parked out of the way. The stopping test added the requirements of a large, dry, flat, paved area. There had to be room for the vehicle to be accelerated and stopped which implied a total of about two hundred feet for the stopping test. Care was also taken to provide for a safe run-over area past the stopping lane in the event of a brake failure during the stopping test. The final space requirement was dictated by the

presence of the HSRI wheel-pull area. Room was needed for the vehicle to be parked alongside the HSRI van for the brake inspection. This area had to be sufficiently distant from the stopping lane so that the vehicle could be easily manuvered into position for a wheel-pull and still have a minimum of danger in the case of a run-over form the stopping lane. These space requirements restricted potential sites to those of roadsides with ample space, large parking lots, or "triangle" types of areas.

Sites also had to be chosen for the traffic flow and origin. For purposes of the sample checklane, the flow had to be of mostly local origin (within the particular county) in sufficient volume that about 200 vehicles could be randomly inspected daily. The above requirements limited the sites to those which were feeders into the cities and therefore eliminated some rural areas from the inspection procedures. The actual sites used were assigned randomly to the days in such a manner that the same site was not used on two consecutive days. Table 1 in Appendix A gives the sites used and Table 2 gives the inspection schedule for 1975 and 1976 (several sites were dropped in 1976 because of road construction).

The actual equipment state police needed for the sample checklane can be divided into that required for the inspection and that required for the wheel-pull. The state police needed roadside signs, traffic marker cones, an equipment van, and a chase car for the enforcement officer. The HSRI technicians required a jack, an air wrench, and assorted tools to complete their wheel-pull inspection of the brake. A supply of spare parts for the brakes was also carried. In addition, an air compressor was needed to power the air wrench, a trailer to carry the compressor and jack, and a van needed to store the extra tools and parts as well as to tow the trailer. Most of the HSRI equipment was leased over the course of the summer of 1975.

2.3.4 Publicity. An active publicity campaign was conducted in both counties as an attempt to explain the inspection situation to the uninspected population and encourage good maintenance of the uninspected vehicles. A more intense campaign was conducted in Jackson County, since the sample checklane operated with a higher intensity in that county. Both counties had good coverage of the checklane procedures by the media in the forms of radio, television, and newspaper. Jackson County also had an active billboard campaign combined with a pamphlet given to the drivers of all inspected vehicles to explain the sample checklane. The total publicity campaign was credited with giving an unexpectedly high degree of public cooperation with the state police vehicle inspections and the HSRI wheel-pulls.

2.4 Data Collection and Management

The basic inspection variables were recorded by the MSP on a computer mark-sensing form (Appendix A). The mark-sensing forms were collected by the MSP. The data were read from the mark-sense forms and a magnetic tape of the data was prepared by the MSP.

The data from the wheel-pull inspections (see Appendix A) were keypunched at HSRI and a computer file of these data was also prepared. To prepare the data for analysis, the data file from the from the MSP was merged with the data file from the HSRI wheel-pull inspections. The data from the driver interviews was tabulated and summarized by HSRI. No merging or matching with other inspection results was required.

Appendix B gives the list of variables in the HSRI computer file. Also included are the details of the data storage such as the column locations, variable names and numbers, and notes on recoding.

According to HSRI records, the sample checklane conducted 2,019 inspections in Monroe County and 10,408 inspections in Jackson

County in 1975. Of those 12, 427 estimated inspections, 11,651 inspection results were received by HSRI. An estimated 776 inspection results were lost during the processing of the inspection data from the inspection forms to magnetic tape. Due to a clerical error, approximately 200 of those 11,651 results had the form numbers changed. Thus, approximately 976 (about 7.8%) of the data collected in 1975 are missing or miscoded.

Again, according to HSRI records, 2,536 wheel-pull brake inspections were conducted in 1975. Of those 2,536 estimated inspections, the form numbers of 2,317 inspection results about 91.4% matched the form numbers on the tape that we received from the Michigan State Police. Of the 219 unmatched brake results, 198 appear to be due to MSP missing or miscoded records, and 21 appear to be due to HSRI processing errors.

In 1976, the sample checklane conducted approximately 2200 inspections in Monroe County and 9550 inspections in Jackson County. Of the 9547 inspections in Jackson County, 2519 were re-inspections of cars inspected in 1975 and 7028 were cars inspected for the first time. The exact count of usable inspections is 2139 in Monroe County, 2442 re-inspections and 6768 new inspections in Jackson County. The remaining were lost due to handling or data processing errors. Thus of the data collected in 1976, only about 3.4% were not usable. This represents an improvement in data management jointly between HSRI and the Michigan State Police.

3. ANALYSIS AND RESULTS OF 1975 DATA

This section summarizes the state of repair of the vehicle populations in Monroe and Jackson Counties in 1975. Thus, these data represent the baseline against which the effect of the checklane inspection program will be measured. Comparisons of the vehicle populations sampled in the two counties are presented as well as defect rates.

3.1 Representativeness of the Samples.

The sampling plan presented in Section 2 has certain limitations. It represents an attempt to obtain a random sample of vehicles operated locally. This population of vehicles is not necessarily the same as the population of registered vehicles. In particular, a comparison of the model years between the registered vehicles and the sampled vehicles reveals large differences. The distribution of model year for sampled and registered vehicles is given in Tables B-1 through B-3 in Appendix B. In general, fewer older vehicles were found in the sample than expected from the distribution of registered vehicles, and correspondingly, more newer vehicles than expected were observed.

There are a number of possible interpretations of this observation. One is that the sampling procedure selects vehicles with probability proportional to their current usage and hence is a sample of the population of vehicles actually being used. As such, the sample would accurately represent the appropriate target group, since the more a vehicle is used, the more important it is that it be in safe mechanical condition.

An alternative interpretation is that the population of vehicles which uses the roads suitable for checklane sites at the hours when the checklane operates is different from the general population of vehicles in use. This could be the case if particular

ages of vehicles are used predominantly for long distance and freeway driving on predominantly rural, low volume roads. To the extent that this is the case, this represents a limitation of the checklane inspection program's ability to reach the intended population. It is conceivable, though unlikely, that the differences result from deliberate attempts to avoid the checklane. It is not possible with these data to determine why the sampled population differs from the registered vehicles. The assumption is made that it represents differences in use by different types of vehicles, and hence that the checklane sample is at least as representative of the population of vehicles in use as the reigstration list.

It should be noted, however, that even if the population observed by the sample checklanes is not the same as the population of registered vehicles, this will not offset the primary comparisons of the project adversely. That is, the measured effect of the checklane will be observed in the sampled population. Similarly, the effect of the PMVI will be observed in the sampled population and comparisons between these will be based on similar populations. Thus, the estimates of effects are based consistently on the sampled populations.

Since it is hoped to make cross-county comparisons, it is important to compare the sampled population of vehicles in Jackson and Monroe Counties. Several comparisons of the sampled vehicles were made and are reported in detail in Tables B-4 through B-7 of Appendix B.

No significant difference was found in the distribution of vehicle types. A slight difference in reported mileage was observed ($p=.044$), with vehicles in Jackson County having slightly greater mileages. In view of the large sample sizes and small difference in mileage, this is probably not of practical importance. A somewhat more significant difference in the distribution of model years was found ($p=.013$). This difference is rather small, but may be important since defect rates have been found to vary considerably by model year. A very large difference in the distribution

of vehicle makes was found. The relevance of this to the defect rates is uncertain at this point but will be considered in making the comparisons.

The overall defect rate in the two counties are given in Table 3.1.

TABLE 3.1

Total Vehicle Defect Rates

	County		
	Monroe	Jackson	Total
Percent Passing	48.1	50.5	50.1
Total	1786	9865	11651

The difference was not significant at the 5% level (p=.062), however Jackson County did exhibit a slightly better passing rate. Since Jackson County also had slightly higher mileage and older vehicles, it appears that the affects of the age differences between the two counties were not very pronounced. That is, it may not be necessary to adjust for age between the two counties.

Overall, the two counties seem to be quite similar in the population of vehicles sampled by the checklanes. The largest difference lies in the make of the vehicles. This probably reflects differences in availability and dealer agressiveness in the two areas. It does not appear to be closely connected with condition of vehicles.

3.2 Defect Rates. The selective random checklane used by the Michigan State Police inspects about 300,000 vehicles annually for an overall intensity of about 5 to 10 percent. The population from which our sample was drawn thus represents an inspection system with no mandatory inspections and a low proportion of actually inspected vehicles. The data reported in this section represent the pooled data over the course of the summer of 1975 for Jackson and Monroe Counties.

Vehicles were inspected on twenty three items (Table 3.2). The total sample size for this police inspection from June to October 1975

was 12,315 vehicles from vehicle model years 1960 to 1976. Rates of pass and fail were tabulated on these variables, as well as on seven derived variables. The derived variables were formed on each general defect category which had more than one sub-category (lights, exhaust, brakes, tires, glass, wipers and washers) such that a failure in any one of the sub-categories was counted as a failure in the derived variable. A final derived variable was added for the total vehicle such that a failure in any category gave a fail in the total vehicle.

An analysis by vehicle age for some of the above variables was performed. It was found that all the inspected vehicles passed on the safety glass and beam indicator so these variables as well as total glass were deleted. The test for foot brake was replaced by another part of the experiment and so was not included in the analysis. For this reason, the variable for total brake also was not included in this analysis.

TABLE 3.2

Police Inspected Items

Inspection Variables	
Glass	Lights
Safety	Front Directional
Vision Impaired	High Beam
Wipers and Washers	Low Beam
Wipers	Aim of Headlight
Washers	Output
Horn	Tail
Steering	Stop
Brakes	Rear Directional
Foot	Plate
Parking	Beam Indicator
Tires	Exhaust
Bulges or Break	Noisy
Tread	Smoke
	Mirror

3.2.1 Total Vehicle Defects. We developed a descriptive model relating the total vehicle failure rate to the model year of

the vehicle. The dependent variable is the proportion of vehicles failing on at least one component. The independent variable is the model year (or equivalently, the age) of the vehicle. The age is computed as the difference between 1976 and the model year of the vehicle. For example, a car with model year 1970 is regarded as having an age of six years.

Table 3.3 gives the data. The proportion failing is plotted against age (model year) in Figure 3.1. An increasing trend of the proportion of vehicles failing inspection is apparent. Since the dependent variable is a proportion which changes considerably, and since the sample sizes are unequal, the variances are also unequal. This implies that the usual regression or least squares method of fitting a trend line is not appropriate. Instead, weighted least squares has been used. The details of this statistical technique are summarized in Appendix E.

TABLE 3.3

Observed Results on Total Vehicle
Model Years 1960-1976

Year	Age	Pass	Fail	Total
1976	0	27	0	27
1975	1	1151	148	1299
1974	2	1406	484	1890
1973	3	1241	757	1998
1972	4	862	850	1712
1971	5	579	690	1169
1970	6	358	623	981
1969	7	270	753	1023
1968	8	149	599	748
1967	9	86	466	552
1966	10	44	341	385
1965	11	28	242	270
1964	12	18	126	144
1963	13	7	46	53
1962	14	4	38	42
1961	15	0	12	12
1960	16	0	10	10

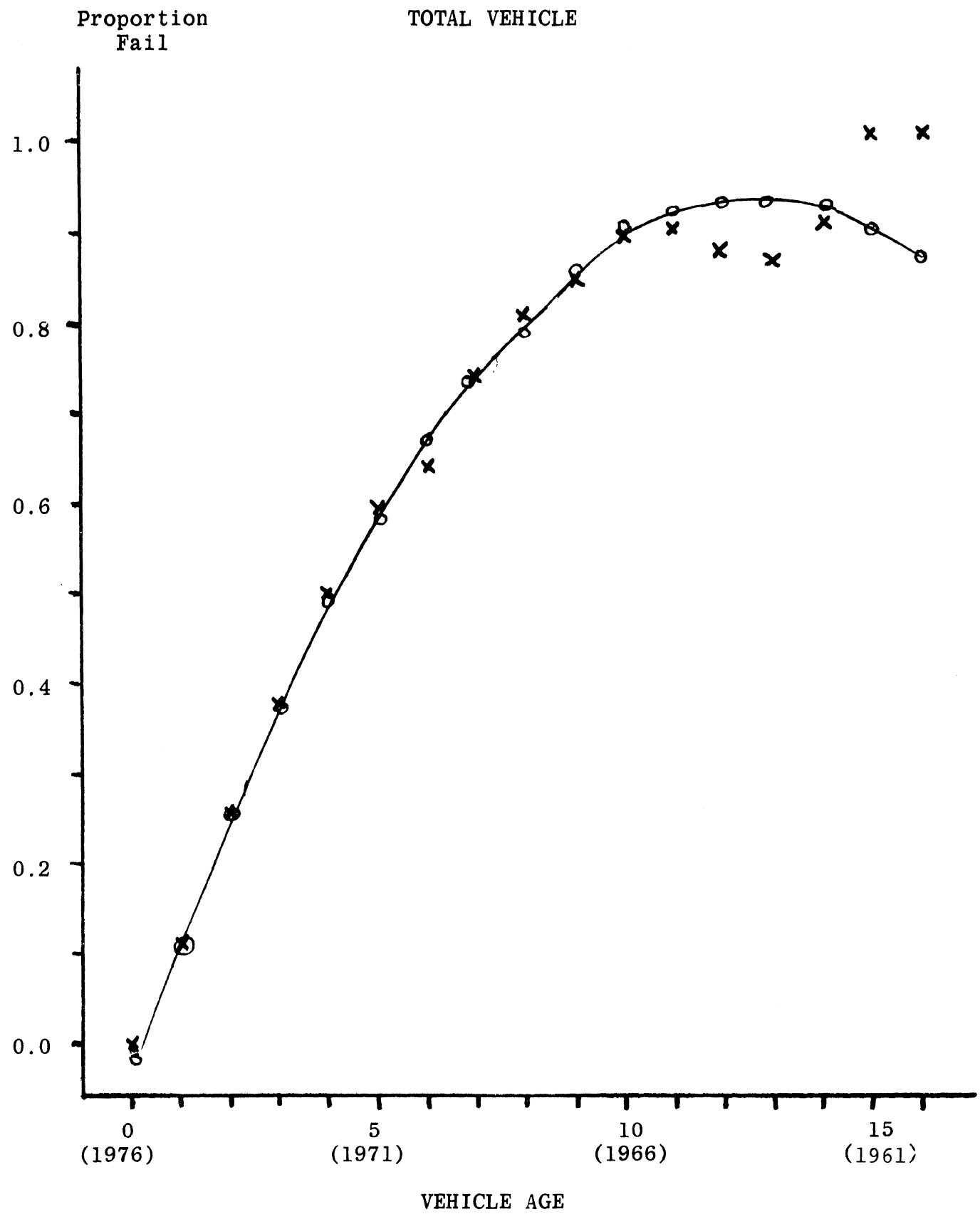


FIGURE 3-1

Observed Failure Rates for Total Vehicle,
Model Years 1960 - 1976

The results indicate that the relationship of proportion defective to age is best described by the model:

$$Y = -0.018 + 0.149\ X - 0.006X^2,$$

where X is the age in years and Y is the proportion defective. The linear model:

$$Y = 0.1185 + 0.077X$$

has nearly the same predicted power, but shows a significant lack of fit. Details of the model derivation may be found in Appendix C.

The main conclusion to be drawn from this regression model seems to be that there is a strong increase of defective vehicles with age. The exact form of the relationship may not be of primary interest. However the model provides a concise summary of what proportion of defective vehicles one should expect for a given age of vehicles.

Models of this sort also have potential utility in making policy decisions regarding vehicle inspections. For example, if it were determined that to be cost-effective an inspection should not be applied to a population of vehicles unless the defect rate were at least 25%, the model would indicate that only vehicles over two years old would be inspected.

3.2.2 Specific Components Defects. It might be that some specific component or some other combination of components would be considered an appropriate criterion for determining what set of vehicles should be the target of an inspection program. The percent defective for each model year are plotted for several specific defects in Figures B-1 through B-24 of Appendix B. Also in Table B-9 of Appendix B are detailed tables of the number and percent of vehicles with each specific defect for each county.

Most defect rates show an increase with the age of the vehicle. However a few, such as headlight output, steering, tire bulges or breaks, and exhaust smoke, are so rare that the tendency of the proportion to increase with age is hard to verify.

In Monroe County 10.2 percent of the drivers seen in the random checklane said that they had been previously inspected in a checklane. In Jackson County only 4.6 percent had had previous experience with a checklane inspection. Overall, 5.4 percent of the drivers had been through a checklane previously. This figure agrees with the statewide operational inspection rate of 5-6 percent.

Defects Relating to Vision. All of the vehicles seen in the random checklanes had approved safety glass in the windshield and windows. In both counties combined, 3.6 percent of the vehicles had vision impaired due to cracked or chipped windshields. Monroe County vehicles had a 2 percent rate while Jackson County vehicles had a 3.9 percent rate of defects. The incidence of this defect increases only moderately with the age of the vehicle remaining at about 3 percent until the vehicle is six years old or so. In the older vehicles the rate tends to be around eight percent, but was variable.

Windshield wipers were defective on 3.4 percent of the vehicles in Monroe County, and 3.6 percent of the vehicles in Jackson County, giving a combined rate of 3.6 percent. For windshield washers, the defect rates were 19.5 percent in Monroe, 15.3 percent in Jackson for a combined rate of 16.0 percent. Overall, 18.1 percent of the vehicles had either the windshield wipers or washers defective. Both wipers and washer defect rates show strong, nearly linear increases with age of the vehicles, however, the wiper rates were quite variable and were about a third of the washer rates.

About 2.4 percent of the vehicles observed had defective or insufficient mirrors. An increasing, nearly linear, trend with age was noted, rising from a rate of near zero for new cars to about six percent for vehicles ten years old.

Combining the vision defects, 78.5 percent of the vehicles had no vision related defects. Eighteen percent had one vision defect and 3.5 percent had two or more. The rates of all defective vehicles showed a marked tendency to increase with the age of the vehicle.

Lighting Defects. Only four of the 11,651 vehicles sampled had a non functional beam indicator light. Thus this component almost never fails. Headlight output was insufficient in only 1.3 percent of the vehicles. The output showed little relationship to age, being at most only about 4.0 percent in model years with sufficient sample size to give a reliable rate.

Headlight aim was faulty in 9.7 percent of the vehicles. This rate showed a linear trend increasing with age to about 7.0 percent for 10 year old vehicles. Low beams were out in only 2.4 percent of the vehicles, while high beams were out in 7.3 percent of the vehicles. The high beam outage rate showed a strongly increasing linear trend with age. On the other hand, the low beam outage rate was more variable and showed a smaller slope in its increase with age. In general the low beams were satisfactory in more cars than the high beams. This may reflect a much higher use of low beams than of high beams in this population. If so, then the indication is that drivers notice low beam headlight outages--and repair them--more readily than high beam outage. Overall 93.8 percent of the vehicles had satisfactory headlights.

Five percent of the vehicles had defective front directional lights and 6.9 percent had defective rear directional lights. The difference may be due to the relative ease of noticing bulb failures in the front directional lights. Both front and rear directional lights show a linear increase in defect rates with age. Front outages reach a high of about 11 percent for 10 year old vehicles, while rear outages range up to about 20 percent at 10 years.

Tail lights were defective in 6.2 percent of the vehicles, while stop lights were defective in 7.2 percent of the vehicles. Both of

these defects showed linear trends, rising to about 12 percent defective in 10 year old vehicles. In vehicles older than 10 years, the rates were quite variable.

The license plate light had the highest rate of defects, 16.8 percent. This is probably due to a combination of factors. It is not readily noticed by an owner, and its repair is probably not regarded as urgent.

Only 67.7 percent of the vehicles had all lights functioning. However 79.8 percent had no major light defects. (Major light defects were directional lights, stop and tail lights, high and low beam headlights, or insufficient headlight output.)

Exhaust Defects. Of the vehicles inspected, 8.8 percent had excessive noise and 1.2 percent had excessive smoke. The noise rate exhibited a generally linear increase with age, rising to a rate of about twenty percent for 10 year old vehicles. The rate of excessive smoke was virtually zero for the first 5 or 6 years after which it varied widely among different ages. It ranged from zero to about 7 percent, averaging about 4 percent in cars over 6 years old.

Control Defects. Steering defects were recorded in 0.3 percent of the vehicles. The rate of steering defects is so low that no specific trend with age is rated, although the rates have been plotted by model year in Appendix B.

The foot brake was recorded as defective in one percent of the vehicles. A comparison of the moving stopping test with the wheel pull method of testing the braking capability of the vehicles is presented in Section 3.3. The determinations there are thought to be much more precise than this variable. There 18.2 percent of the vehicles were found to be defective, however, this was not determined separately for different model years. Ten percent of the vehicles were found to have defective parking brakes. This also showed an increasing trend with vehicle age.

Twelve percent of the vehicles had at least one tire with insufficient tread. Only 0.3 percent of the vehicles had tire bulges

or cord breaks. The percentage of cars with insufficient tread (bald tires) showed an increasing trend with age, however the percent with tire bulges or breaks was too small to determine any tread with vehicle age. Tire pressures were also measured on the subsample of vehicles which had a wheel pull inspection. Distributions of the tire pressures are reported in Table B-10 of Appendix B. No satisfactory definition of what constituted incorrect tire pressures has been determined, so tire pressure was not recorded as a vehicle defect.

Overall, 87.2 percent of the vehicles had no control defects.

Miscellaneous Defects. Three percent of the vehicles were found to have defective horns. This variable also showed a linear increase with age, ranging from zero for new cars to about 9 percent for ten year old cars.

All but 1.5 percent of the drivers had valid operating licenses, and only 0.2 percent did not have proper vehicle registration. A total of six improper registrations were detected. A total of three failures to comply with insurance were found. However these results are not thought to be representative of the state, since the vehicles sampled do not come from any central city areas nor generally from completely rural areas. A citation was issued in 1.3 percent of the cases. Seat belts were observed in use by 11.4 percent of the occupants. However this is thought to be somewhat unreliable. It is probably an underestimate, since some drivers may have unbuckled them to get drivers licenses or registration papers before the officer reached the car.

3.2.3 Post Card Return Rates by Defect. Operators of vehicles with at least one defect were given a postcard to return certifying that the defect had been repaired. A total of 6,200 postcards were issued, of which 3,700 were returned. Thus 59.7% of the operators returned a postcard certifying that all defects noted had been repaired within 21 days.

The rate of return of post cards is not a totally satisfactory measure of the repair rate. A measure which was independent of the driver (owner) would be preferable, but was not available. (The sample results in 1976 from previously inspected cars will provide an independent estimate of the repair rate--which lasted a year). It may be that not all of the postcards returned actually had the repairs made. What seems more liekly, however, is that many repairs were made but the cards were not returned--perhaps because they were mislaid or forgotten until after the 21 day period.

An attempt was made to estimate the actual repair rates through a subsample. A random sample of 400 vehicles for which postcards were issued was drawn. Of these, 204 or 51% returned the postcards. There was no way to trace the other 196 for an interview. Of the 204 returns, 62 could not be matched with a name and address, 47 had no listed telephone, and 95 had telephone numbers. Of the 95, we were able to contact 30 (during regular working hours). Of the 30, the interviewer concluded that all had actually repaired the defects. However, the large non-response rate precludes much confidence in this result.

Table 3.4 tabulates the return rates by types of defect. These rates were estimated from the sample of 400 post card vehicles. Lights had the highest return rate, closely followed by mechanical. Vision and control variables had somewhat lower return rates. Looking at the return rates by number of defects found in the total inspection, one notes a decreasing rate of return with increasing numbers of defects. Thus there may be some indication that the cars with several defects are not repaired as well as a result of the inspection as are those with fewer defects.

It should be noted that vehicles which were issued citations were not issued postcards. Thus the 1.3 percent of the vehicles with the most serious defects--from the safety standpoint--were repaired or the owner faced a court appearance and fine.

TABLE 3.4

Rate of Post Card Return by Defect

Defect Type	% Return
Vision	44.9
Control	44.6
Light	56.2
Mechanical	55.4

Number of Mechanical Defects	% Return
1	55.3
2	56.4
3	47.1
4+	40.4

Number of Light Defects	% Return
1	60.4
2	49.1
3	57.1
4+	35.7

Total Inspection Defects	% Return
1	57.7
2	54.1
3	49.2
4+	41.4

3.3 Driver Interview Results

Druing operation of the sample checklane.in 1975, a driver interview was conducted. The subsample of drivers whose vehicles were selected for the wheel pull brake inspections was used for this purpose.

The two-page interview as shown in Appendix A was given during the months of June and July, 1975. In August, a special second page replaced that shown for use by the Office of the Secretary of State and was not processed by HSRI. The final month and a half of the checklane had only the first page used (question 1-5) due to the absence of researchers at the checklane and as a time consideration. The absence of the second page for much of Jackson County explains the large numbers of missing values for questions 6 through 12. The questions deal with two topics: the sample checklane and opinions. Detailed results of this questionnaire are tabulated in Appendix B as Table B-11.

The results of the age and sex answers show similar patterns for the samples from each county. Both of the counties have the bulk of the drivers under 35 years old and male. The percentage male was more pronounced in Monroe County (60.2%) than in Jackson (56.3%), however.

Questions one and two dealt with driver knowledge of the Michigan Vehicle Inspection Program. The first question related to how the vehicle was to be inspected, with a correct response of "to allow the police to check it at any time." There was a marked increase in the correct responses from Monroe to Jackson Counties (51.0% to 63.6%) attributed to the more intense publicity campaign in Jackson County. Similarly, there was an increase in the correct responses for the second question on how often the vehicle must be inspected. The increase from 35.0% to 48.8% in Monroe and Jackson Counties, respectively, is explained in the same manner as above.

Questions three and four related to where and when the driver had heard about the Michigan inspection program. The press

campaign was again evident in the proportions of the drivers who had not heard of the MVIP, as 7.5% in Monroe County had not compared to 1.9% in Jackson County. Other evidence is the proportion of the drivers who had heard about the checklane from the press (52.1% in Monroe County, 74.6% in Jackson County. Both counties had over 90% of the population who had heard of the checklane sometime before the day of the interview. Some inconsistencies occurred between the questions, because some drivers that heard of the inspection that day as they went through the inspection marked that they had heard of the checklane from the police in question 3 and "today" on question 4.

Question five was a check installed to ensure that the bulk of the traffic was of mostly local origin for the design purposes. The responses indicated that there was less than 20% non-county traffic for each county. This indicates that a sizeable number of inspected vehicles may be recovered in Jackson County.

Questions six through eight related to seat belt usage. There seemed to be a trend of less usage in Monroe County than in Jackson County. Fewer drivers in Monroe County reported they "always" or "often" wore seat belts (16.8% and 22.3%) than did drivers in Jackson County (21.1% and 26.7%). It is interesting to note that the troopers conducting the inspection observed only about 11 percent of the drivers to be wearing seat belts. Part of this difference may be due to the driver having removed the belt by the time the trooper reached the car, but it seems likely that there was a bias toward over-reporting of usage. At least the reported usage seems higher than the actual usage in the particular driving situation at the checklane site.

More drivers in Monroe County felt inconvenienced by seat belts (65.7% vs. 56.8%) than in Jackson County. Over two-thirds (67.3% and 69.3%) of the drivers in both counties agreed that seat belts save lives.

Questions nine through twelve referred to the 55 mph speed limit. Drivers in both counties strongly felt that the lower speed limit (55 mph) reduces highway fatalities (87.7%). There was a

strong opinion that there should not be a higher speed limit on all state highways (75.0%) and a somewhat weaker feeling for the 55 mph speed limit on the interstate highways (59.0% in favor of maintaining the 55 mph limit). There was somewhat less support for instituting points on driver's license for speeding violations between 55 and 70 mph, with an average of only 54.6% of the drivers agreeing.

It should be recalled that the sampling techniques intended to concentrate on local traffic. Drivers who do most of their driving on interstates were excluded. Similarly most drivers on long trips were excluded. Consequently, these results cannot be generalized to the population of all drivers, but relate to those --in Monroe and Jackson Counties--who do mostly local, short trip driving. A survey taken on interstates might produce quite different results.

There may also be a bias of drivers to report the "officially acceptable" opinion. Although the interviews were not conducted by the MSP, the troopers were much in evidence and this may have influenced the results. The discrepancy between the percent of drivers observed to wear seat belts (11%) and the percent who reported that the "always" (19% or "often" (24%) wore seat belts may reflect this. In the future, randomized response techniques might be utilized to avoid this.

3.4 Brake Inspection Results

3.4.1 The Moving-Stopping Test. All vehicles (except for 1.9% who refused) were given a low speed moving-stopping test. A state trooper accelerated the vehicle to twenty miles per hour, and then attempted to stop it in a lane twenty-five feet long and ten feet wide. The results were recorded in three variables: pedal pressure, ability to stop, and stopping audible. The detailed results of this test are presented in Table B-12 of Appendix B.

It was believed that a fail on any of the three variables indicated a serious brake defect. Consequently a vehicle was judged to pass only if it passed all three. The percent of vehicles passing the moving stopping test was 75% in Monroe County and 83.1% in Jackson County. The most frequent causes of failure were stopping audible and pulling to one side in the moving test.

Table 3.5 gives the percent of vehicles in each county which failed the moving stopping test on each of the three variables. Also included are the overall passing rates and the percentage of vehicles failing on more than one defect.

TABLE 3.5

Moving Stopping Test Results

	Monroe County		Jackson County		Total	
	Count	% Fail	Count	% Fail	Count	% Fail
Pedal Pressure	122	6.9	371	3.7	499	4.1
Stopping Test	212	11.9	738	7.5	950	8.1
Stopping Audible	208	11.6	678	6.9	886	7.6
One Defect	358	20.0	1173	11.9	1531	13.1
Two Defects	68	3.8	217	2.2	285	2.4
Three Defects	16	0.9	60	0.6	76	0.7
Pass	1340	75.0	8195	83.1	9535	81.8

3.4.2 Wheel Pull Inspections. A random subsample of 2,465 vehicles were given a brake inspection by an automotive technician. This inspection was conducted separately and independently of the moving stopping test. It consisted of removing one wheel (the right front wheel) and inspecting the braking system's mechanical components. The detailed results are tabulated in Table B-13 of Appendix B. One interesting observation is that cars in Monroe County had a different distribution of brake types than did those in Jackson County. This may correspond to the differences in makes noted between the two counties.

Table 3.6 gives the number and percent of vehicles failing by each cause for the two counties.

TABLE 3.6

Wheel Pull Inspection Failures

	Monroe Co.		Jackson Co.		Total	
	Count	% Fail	Count	% Fail	Count	% Fail
Brake Fluid	12	4.1	74	3.7	86	3.8
Shoe/Pad	3	1.3	83	4.4	86	4.1
Rotor or Drum	10	4.2	158	8.5	168	8.0
Wheel Cylinders	8	3.4	7	0.4	15	0.7

3.4.3 Comparison of the Wheel Pull and Moving Stopping Test.

The main aim of the wheel pull inspections was to provide a comparison between the mechanical inspection and the moving stopping test as methods for determining the braking capability of the inspected vehicles. To do this is was necessary to define a pass-fail criterion for the wheel pull inspection. Three possible criteria for this pass/fail variable were considered:

WPI 1 = Fail if shoe/pad fail, or cracked rotor/drum, or wheel cylinders fail

Pass otherwise

WPI 2 = Fail if WPI 1 fail, or low master cylinder fluid

Pass otherwise

WPI 3 = Fail if WPI 2 fail, or worn rotor/drum

Pass otherise

Due to their nested quality, a vehicle that fails WPI 1 must also fail WPI 2, and a vehicle that fails WPI 2 must also fail WPI 3. Conversely, a vehicle that passes HSRI 3 must also pass WPI 2, and a vehicle that passes WPI 2 must also pass WPI 1. The results of the two tests jointly are presented in Table 3.7.

TABLE 3.7

Brake Inspection Results

		WPI 1		
		Pass	Fail	Total
MST	Pass	1825	62	1887
	Fail	534	44	578
	Total	2359	106	2465

		WPI 2		
		Pass	Fail	Total
MST	Pass	1773	114	1887
	Fail	503	75	578
	Total	2276	189	2465

		WPI 3		
		Pass	Fail	Total
MST	Pass	1749	138	1887
	Fail	491	87	578
	Total	2240	225	2465

The policy issue that the analysis is meant to examine is whether the stopping test is an adequate brake inspection, or whether it is necessary to remove a wheel in order to perform an adequate brake inspection. Therefore, the objective is to provide estimates of the probability that a serious brake defect will be discovered by a wheel pull inspection for vehicles that had passed the stopping test.

An additional objective of the analysis is to examine whether a wheel pull inspection is adequate, or whether it is also necessary to conduct a stopping test. Therefore, we also wish to estimate the probability that a serious brake defect will be discovered by a stopping test for vehicles that had passed the wheel pull inspection.

Note that the wheel pull is not a complete inspection of the brakes. Only one wheel is inspected. Inspection of all 4 wheels would give a complete description of the mechancial condition of the brakes, but might not detect a tendency of the car to pull to one side while stopping. However inspection of all four wheels would add a great deal of time and effort to the inspection.

From Table 3.7 it is simple to calculate the percent of vehicles which passed the moving stopping test, but failed the wheel pull inspection (by the WPI 1, 2, or 3 criteria). This percent is an estimate of the unsafe vehicles which pass the moving stopping test. Table 3.8 gives these percents, together with their joint 95% confidence intervals. (Derivation of the confidence intervals is complex. It is presented in Appendix C.) Even using the most conservative criterion--the one that most favors the wheel pull--at most 9.1% of the vehicles which pass the moving stopping test would be unsafe. And the best estimate is that only 7.3% would be unsafe. We believe that the most reasonable pass/fail criterion is WPI-2. This estimates that 6% of unsafe vehicles would fail the moving stopping test, and one is 95% confident that at most 7.7% of the vehicles passing would have unsafe brakes.

TABLE 3.8

Estimated Percent Vehicles Passing Moving Stopping Test which have Unsafe Brakes

	Percent	95% Confidence Intervals
Unsafe by WPI-1	3.3	(2.0 to 4.6)
Unsafe by WPI-2	6.0	(4.3 to 7.7)
Unsafe by WPI -3	7.3	(5.4 to 9.1)

The other approach is to ask "if the wheel pull inspection were used, what proportion of vehicles passing the wheel pull inspection would have stopping defects?" That is, of those vehicles passing the wheel pull, what percent would fail the moving stopping test. Table 3.9 gives estimates of these percents for each of the 3 criteria together with the joint 95% confidence intervals.

Inspection of Table 3.9 reveals that if the wheel pull inspection were used, at least 19.8 percent of the vehicles passing the wheel pull would have stopping defects as judged by the moving stopping test.

If the WPI-2 criterion for passing is used, an estimated 22.1% of the vehicles which passed could have stopping defects.

TABLE 3.9

Estimated Percent of Vehicles Passing the Wheel Pull which have Stopping Defects

	Percent	95% Confidence Interval
WPI-1	22.6	20.5 to 24.7
WPI-2	22.1	20.0 to 24.2
WPI-3	21.9	19.8 to 24.0

Thus, if the criterion for the brake inspection is to avoid passing vehicles which have stopping difficulties, the moving stopping test is more efficient. Even if the criterion most favorable to the wheel pull is used, the proportion of defective vehicles that would be undetected by the moving stopping test is less than 9.1 percent, while the proportion of defective vehicles that would be undetected by the wheel pull is more than 19.8 percent. Since the moving stopping test is also easier and faster to conduct, it seems the preferred choice.

3.4.4 Further Comparisons of Brake Tests.

This section investigates further the relationships between the wheel pull brake test and the moving-stopping and stationary brake tests. The investigation should indicate the validity of assumptions about actual brake conditions based on routine moving-stopping test results.

The stationary brake test involved merely testing the foot brake to see if it functioned. The moving-stopping test involved accelerating the vehicle to twenty miles per hour and then attempting to stop in a space twenty five feet long and ten feet wide. Both of these tests were performed on all vehicles inspected in 1975. The wheel pull test involved examining the master cylinder reservoir fluid level and then removing the right front wheel and inspecting the brakes. This test was performed on a random sample of 2,465 vehicles.

It is not realistic to assume that all four brakes on a vehicle are in the same condition as the right front brake; so these comparisons are not complete. In spite of this drawback, useful insights into the relationships between the tests can hopefully be obtained from the data at hand.

In this investigation the following two questions are of general interest:

1) What inferences can be made about actual brake conditions, based on stationary and moving-stopping test results?

2) How sensitive are the tests to known brake defects?

It is difficult to obtain definitive results from all brake comparisons for question (1) due to the fact that all brakes were not tested. Good answers, however, can be obtained for question (2) since one known defective brake should be sufficient to affect test results.

These questions can best be answered by examining two-way tables such as Tables 3-10 to 3-18. Since the tables may appear confusing at first, a brief explanation is in order. A column of "Col %" figures sums to 100% and a row of "Row %" figures sums to 100%. The "Col %" figures are the breakdown

of the wheel-pull test results for each outcome of the stationary or moving-stopping test. These are the data which give insight into question (1). For example, in Table I, of the 204 vehicles which failed the Stopping Audible test, 68.1% passed the Shoe-Pad Thickness test, 12.7% had between 50 and 75% of the pad, 10.8% had between 1/32 inch and 50% of the pad, and 8.3% failed the test. A comparison of this column with that for vehicles which passed the Stopping Audible test will indicate the effectiveness of the Stopping Audible test in pointing out shoe-pad deficiencies. The "Row %" figures are the breakdown of the moving-stopping test results for each outcome of the wheel-pull test. These data suggest the sensitivity of the tests to various known defective components. For example, in Table I, of the 86 vehicles which failed the Soe-Pad Thickness test, 80.2% passed the Stopping-Audible test and 19.8% failed.

The column of "Overall" percentages is the total breakdown of the various wheel-pull results. The "Total" row of percentages breaks down the moving stopping or stationary test results.

Tables 3-10, 3-10a, 3-11 and 3-11a are for the Stopping Audible part of the moving-stopping test. By comparing the "Col %" figures for those vehicles which passed the Stopping Audible test with the figures for those vehicles which failed, one can see that the vehicles that passed fared better in the Shoe-pad Thickness test. These figures suggest that vehicles that fail the Stopping Audible test are more likely to have defective shoe-pads than are vehicles which pass the Stopping Audible test.

Due to the fact that only one brake was tested, it is perhaps more important to examine the likelihood of a vehicle failing the Stopping Audible test given that there is at least one defective shoe-pad. In this study 19.8% of the vehicles with at least one thin shoe-pad failed the Stopping Audible test. This figure is low enough to suggest that the Stopping Audible test is not very useful as an indicator of shoe-pad condition. This statement is reinforced by Table 3-10a where the breakdown of shoe-pad thickness for vehicles which failed only the Stopping Audible portion of the moving-stopping test is very similar to the breakdown for vehicles which passed the Stopping Audible test.

Tables 3-11 and 3-11a compare the Stopping Audible test with the Rotor or Drum test. As would be expected, these tables show a very weak relation between Stopping Audible and rotor or drum condition. The figures in Table 3-11a are very similar to the figures for vehicles that passed Stopping Audible. These four tables suggest that the Stopping Audible test is inefficient at detecting serious brake trouble.

Tables 3-12, 3-13, and 3-14 show how well the stopping test worked as an indicator of deficiencies in master cylinder fluid level, shoe-pad condition, and rotor or drum condition. In these tables the number of vehicles which failed the stopping test due to both side-to-side motion and an inability to stop was too small for useful analysis (13 vehicles) and so has been included in the "Cannot Stop" column. The tables show that an inability to stop is associated with low master cylinder fluid level, a grooved rotor or drum, and thin shoe pads. None of these associations are strong enough to be useful for predictive purposes however. The strongest relationships here appear to be between vehicles which have side-to-side motion (pulling) during stopping and either a grooved rotor or drum or a thin shoe pad. This seems logical, but even though the relationship does exist, it is still hardly strong enough to be useful for inferences (67.4% of the vehicles with at least one thin shoe pad still passed the stopping test). These tables indicate that the stopping test does not accurately reflect master cylinder fluid level.

Tables 3-15 and 3-16 show the relationships between the pedal pressure test and the tests for master cylinder fluid level and shoe-pad condition. Because of small group sizes and the similarity of the categories, it is helpful here to combine the figures for "Soft", "Low", and "Pressure Loss". Doing this in Table 3-15 one finds that of 110 vehicles in this group, 74 of them (67.3%) had full cylinder reservoirs, 25 (22.7%) had half-full reservoirs, and 11 (10%) had low fluid levels. This indicates that vehicles which failed the pedal pressure test were more likely to have half or low fluid levels, but the relationship is fairly weak since 67% of these vehicles had full reservoirs. A similar weak relationship occurs in Table 3-16 if the same aggregation of failure categories is made. Of the 93 vehicles which failed

TABLE 3-10

Stopping Audible vs. Shoe-Pad Thickness

Thickness/Stopping		Pass	Fail	Overall	(Count)
Pass (>75%)	Col %	81.3%	68.1%	80%	(1684)
	Row %	91.7%	8.3%		
50%-75%	Col %	9.7%	12.7%	10%	(211)
	Row %	87.7%	12.3%		
1/32"-50%	Col %	5.4%	10.8%	5.9%	(124)
	Row %	82.3%	17.7%		
Fail (<1/32")	Col %	3.6%	8.3%	4.1%	(86)
	Row %	80.2%	19.8%		
Total		90.3%	9.7%		
(Count)		(1901)	(204)		(2105)

TABLE 3-10a

Shoe-Pad Thickness Test Results for Vehicles which Failed Only Stopping-Audible on Moving-Stopping Test

Thickness	
Pass (>75%)	72.4%
50%-75%	13.4%
1/32"-50%	8.2%
Fail (<1/32")	6.0%
(Count)	(134)

because of a soft or low pedal or because of pressure loss, eight of them (8.6%) had less than 1/32 inch of shoe-pad and 65 (70%) had more than 75% of their shoe-pad left. These tables stated that the pedal pressure test is not very useful as an indicator of master cylinder fluid level or of shoe-pad condition. This lack of predictive power is made especially obvious by the facts that 89.5% of the vehicles with a failing shoe-pad and 86% of the vehicles with low fluid level passed the pedal pressure test.

Tables 3-17 and 3-18 show the relationships between the foot brake test and the master cylinder fluid and shoe-pad tests. Meaningful cause/effect relationships are difficult to detect here because of the small number of vehicles that failed the foot brake test. The "Col %" figures in Table 3-18 show a fairly strong relation between the foot brake test and the shoe-pad thickness test. Note that 26.8% of the vehicles (11 vehicles) that failed the foot brake test also failed the shoe-pad test, whereas of the vehicles which passed the foot brake test, only 3.6% failed the shoe-pad test. It must also be noted however in the "Row %" figures, that 87.2% of the vehicles with at least one thin shoe-pad passed the foot brake test.

In examining the study data for other relationships, one finds many similar weak correspondances between even seemingly unrelated variables (i.e., between tire tread and shoe-pad thickness). This suggests that the relationships in Tables 3-10-3-18 may be due to the fact that some owners keep their vehicles in much better general repair than do other owners. The effect of this is that vehicles with one defective component are more likely to have other failures-whether or not there is a cause/effect relationship.

The overall results of this study are that there are few, if any, useful (predictive) correspondances which can be drawn between the moving-stopping and stationary brake tests and the actual condition of the brakes as discovered by the wheel-pull test.

TABLE 3-11

Stopping Audible vs. Rotor or Drum Condition

Rotor, Drum/Stopping		Pass	Fail	Overall	(Count)
Pass	Col %	91.6%	82.7%	90.7%	(1901)
	Row %	91.2%	8.8%		
Cracked	Col %	.1%	.5%	.1%	(3)
	Row %	66.7%	33.3%		
Worn	Col %	1.2%	3.0%	1.3%	(28)
	Row %	78.6%	21.4%		
Grooves	Col %	7.2%	13.9%	7.8%	(164)
	Row %	82.9%	17.1%		
Total		90.4%	9.6%		
(Count)		(1894)	(202)		(2096)

TABLE 3-11a

Rotor or Drum Condition Results for Vehicles Which Failed only Stopping Audible in Moving Stopping Test

Condition	
Pass	89.5%
Cracked	0.0%
Worn	2.3%
Grooves	8.3%
(Count)	(133)

TABLE 3-12

Stopping Test vs. Master Cylinder Fluid Levels

Cylinder/Stopping		Pass	Cannot Stop	Side-to-Side	Overall	(Count)
Full	Col %	87.8%	70.5%	82.0%	86.8%	(1970)
	Row %	88.0%	1.6%	10.4%		
Half	Col %	8.7%	18.2%	13.6%	9.4%	(213)
	Row %	80.3%	2.2%	16.0%		
Low	Col %	3.5%	11.3%	4.4%	3.8%	(86)
	Row %	81.4%	5.8%	12.8%		
Total		87.0%	2.0%	11.0%		
(Count)		(1975)	(44)	(250)		(2269)

TABLE 3-13

Stopping Test vs. Rotor or Drum Condition

Rotor,Drum/Stopping		Pass	Cannot Stop	Side-to-Side	Overall	(Count)
Pass	Col %	92.3%	56.6%	83.1%	90.7%	(1901)
	Row %	88.7%	1.4%	9.8%		
Cracked	Col %	.1%	0.0%	.4%	.1%	(3)
	Row %	66.7%	0.0%	33.3%		
Wron	Col %	1.4%	4.5%	0.0%	1.3%	(28)
	Row %	92.9%	7.1%	0.0%		
Grooves	Col %	6.2%	31.8%	16.4%	7.8%	(164)
	Row %	68.9%	8.5%	22.6%		
Total		87.2%	2.0%	10.7%		
(Count)		(1828)	(44)	(225)		(2096)

TABLE 3-14

Stopping Test vs. Shoe-Pad Condition

Shoe-Pad/Stopping		Pass	Cannot Stop	Side-to-Side	Overall	(Count)
Pass (>75%)	Col %	81.6%	54.5%	72.1%	80.0%	(1684)
	Row %	88.9%	1.5%	9.7%		
50-75%	Col %	9.8%	16.0%	11.1%	10.0%	(211)
	Row %	85.3%	2.9%	11.9%		
1/32"-50%	Col %	5.4%	13.6%	7.5%	5.9%	(124)
	Row %	80.6%	5.6%	13.7%		
Fail (<1/32")	Col %	3.2%	15.9%	9.3%	4.1%	(86)
	Row %	67.4%	8.2%	24.4%		
Total	87.2%	2.1%	10.7%			
(Count)		(1835)	(44)	(226)		(2105)

TABLE 3-15

Pedal Pressure Test vs. Master Cylinder Fluid Level

Cylinder/Pedal		Pass	Soft	Low	Pressure Loss	Hard	Pul-sating	Overall	(Count)
Full	Col %	88.1%	76.7%	65.8%	42.9%	66.7%	78.9%	86.8%	(1970)
	Row %	94.9%	1.2%	2.4%	.2%	.6%	.8%		
Half	Col %	8.4%	20.0%	23.3%	28.6%	27.8%	21.1%	9.4%	(213)
	Row %	84.0%	2.8%	8.0%	.9%	2.3%	1.9%		
Low	Col %	3.5%	3.3%	11.0%	28.6%	5.6%	0.0%	3.8%	(86)
	Row %	86.0%	1.2%	9.3%	2.3%	1.2%	0.0%		
Total (Count)		93.5% (2122)	1.3% (30)	3.2% (73)	.3% (7)	.8% (18)	.8% (19)		(2269)

TABLE 3-16

Pedal Pressure Test vs. Shoe-Pad Thickness

Shoe-Pad/Pedal		Pass	Soft	Low	Pressure Loss	Hard	Pul-sating	Overall	(Count)
Pass	Col %	80.4%	76.9%	67.8%	62.5%	82.4%	84.2%	80%	(1684)
	Row %	94.4%	1.2%	2.4%	.3%	.8%	1.0%		
50-75%	Col %	10.0%	15.4%	10.2%	12.5%	5.9%	10.5%	10%	(211)
	Row %	93.4%	1.9%	2.8%	.5%	.5%	.9%		
1/32"-50	Col %	5.7%	7.7%	8.5%	25.0%	11.8%	0.0%	5.9%	(124)
	Row %	91.1%	1.6%	4.0%	1.6%	1.6%	0.0%		
Fail	Col %	3.9%	0.0%	13.6%	0.0%	0.0%	5.3%	4.1%	(86)
	Row %	89.5%	0.0%	9.3%	0.0%	0.0%	1.2%		
Total (Count)		93.9% (1976)	1.2% (26)	2.8% (59)	.4% (8)	.8% (17)	.9% (19)		(2105)

TABLE 3-17

Foot Brake Test vs. Master Cylinder Fluid Level

Cylinder/Foot Brake		Pass	Fail	Overall	(Count)
Full	Col %	87.2%	69.0%	86.8%	(1973)
	Row %	98.5%	1.5%		
Half	Col %	9.1%	23.8%	9.4%	(213)
	Row %	95.3%	4.7%		
Low	Col %	3.7%	7.1%	3.8%	(86)
	Row %	96.5%	3.5%		
Total		98.2%	1.8%		
(Count)		(2230)	(42)		(2272)

TABLE 3-18

Foot Brake Test vs. Shoe-Pad Thickness

Shoe-Pad/Foot Brake		Pass	Fail	Overall	(Count)
Pass (> 75%)	Col %	80.6%	51.2%	80.0%	(1685)
	Row %	98.8%	1.2%		
50-75%	Col %	10.1%	7.3%	10.0%	(211)
	Row %	98.6%	1.4%		
1/32"-50%	Col %	5.7%	14.6%	5.9%	(124)
	Row %	95.2%	4.8%		
Fail	Col %	3.6%	26.8%	4.1%	(86)
(<1/32")	Row %	87.2%	12.8%		
Total		98.1%	1.9%		
(Count)		(2065)	(41)		(2106)

3.5 Comparison with 1975 Statewide Inspection Data

In 1975 the State Police inspected 374,738 vehicles in Michigan (Source: Michigan Traffic Accident Facts 1975). Most of these vehicles were inspected in operational checklanes (i.e., at the officer's discretion), not randomly chosen as were the Monroe and Jackson County study vehicles. Since vehicles which are inspected in operational checklanes are often old vehicles or vehicles in obviously poor repair, the failure rates for these vehicles is expected to be much higher than for the randomly selected vehicles.

The table below presents the data for 1975 failure rates.

Table 3.11

Comparison of Operational and Random Checklane Defect Rates by Component

	Statewide (Operational)	Random Checklane
Front Directional Lights	21.0%	5.0%
Rear Directional Lights	20.0%	6.9%
Washers	21.0%	16.0%
Tire Tread	14.0%	12.0%
Emergency Brake	11.0%	10.1%
Operator's License	4.9%	1.5%
Total Count	374,738	11,651

The outage or defect rates observed in the random checklanes are considerably lower for most components. This points out the efficiency of the operational checklane at identifying vehicles with some defective equipment. One exception--emergency brake--is noted in which both outage rates are about equal. This may be due to an inability of the drivers to detect this outage and/or an unwillingness to repair it. Similarly, the outage rates for tire tread are relatively close and may represent a disinclination of drivers to purchase new tires as soon as they should. Outages on washers often is caused by lack of fluid rather than mechanical problems and may represent the perception that washers are not particularly important equipment.

This perception would reasonably result in only occasional checks of fluid levels in washers and the relatively high outage rate.

4. ANALYSIS AND RESULTS OF 1976 DATA

This chapter discusses the data gathered in the 1976 survey in Monroe and Jackson Counties. Defect rates are presented along with data comparing the samples in the two counties. The data presented here are similar to the data presented for the 1975 survey (Chapter 3). Comments in Chapter 3 which explain tests or suggest reasons for failures are applicable to this chapter.

The 1976 sample was drawn from two essentially different populations. The population of vehicles which had not been inspected in 1975 was to be sampled randomly at all inspection sites in both counties. The second population, those vehicles which had been inspected in 1975 in Jackson County, was sampled by inspecting every vehicle with 1975 inspection stickers which were encountered at the random checklane sites. It was necessary to use this sampling scheme in order to insure a large enough sample size.

Most of the data in this chapter are for all vehicles inspected in 1976. The vehicles are analyzed by population type (newly inspected or reinspected) in Chapter 5. For the pruposes of this section combining populations has little effect on the results, but these effects should be mentioned. The population of reinspected vehicles was composed of newer vehicles than was the population of newly inspected vehicles. The reinspected vehicles also tended to be in better repair than the other vehicles even within specific age and mileage groups. These facts are discussed in more detail in Chapter 5.

4.1 Representativeness of the Samples.

As was found to be the case in 1975, the vehicles inspected in 1976 were not representative of registered vehicles in Michigan in 1976. Tables C-1 and C-2 present the data and Chi-square tests of homogeneity between the two

county samples and the Michigan 1976 vehicle registration figures. The tables are for vehicle manufacturer and vehicle age. Tables C-3 through C-6 present comparisons of the samples from the two counties. The comparisons of vehicle type, mileage, and manufacturer show the county samples to be different on these criteria, yet Tables C-5 shows the samples to be similar in vehicle age distribution (p=.2445). Since the county samples were similar on this criterion and since vehicle failure rates have been found to be strongly related to vehicle age, further analyses in the section are conducted with vehicle age as the stratifying variable.

The overall outage rates in the two counties are given in Table C-7. The difference between the failure rates is highly significant here (p=0.00). This difference could be due to the combination of newly inspected and re-inspected vehicles in the Jackson County figure (overall failure rate for the newly inspected vehicles in Jackson County was 57.9%) or it could be due to the fact that the Jackson County sample contained more high mileage vehicles than did the Monroe County sample (Table C-4).

4.2 Defect Rates

The components inspected in 1976 were the same as those inspected in 1975, with the exception that the wheel-pull test was not conducted in 1976. The total sample in 1976 was 11,426 vehicles. Of these, 2,139 were from Monroe County and 9,287 were from Jackson County. Of the Jackson County vehicles, 2,442 were reinspected vehicles.

4.2.1 Total Vehicle Defects. A mathematical model was developed to relate total vehicle failure rates to the age of the vehicle. As with the 1975 data, a weighted least squares regression procedure was used to fit a trend line to the data. Figure C-18 gives the data for newly inspected vehicles. Figure 4.1 shows the data and the fitted trend line for vehicles aged one to fifteen years. A description of the statistical procedure used is in Appendix F.

The relationship of failure rate to age is best described by the equation:

$$Y = -.07 + .169 \times -.007X^2$$

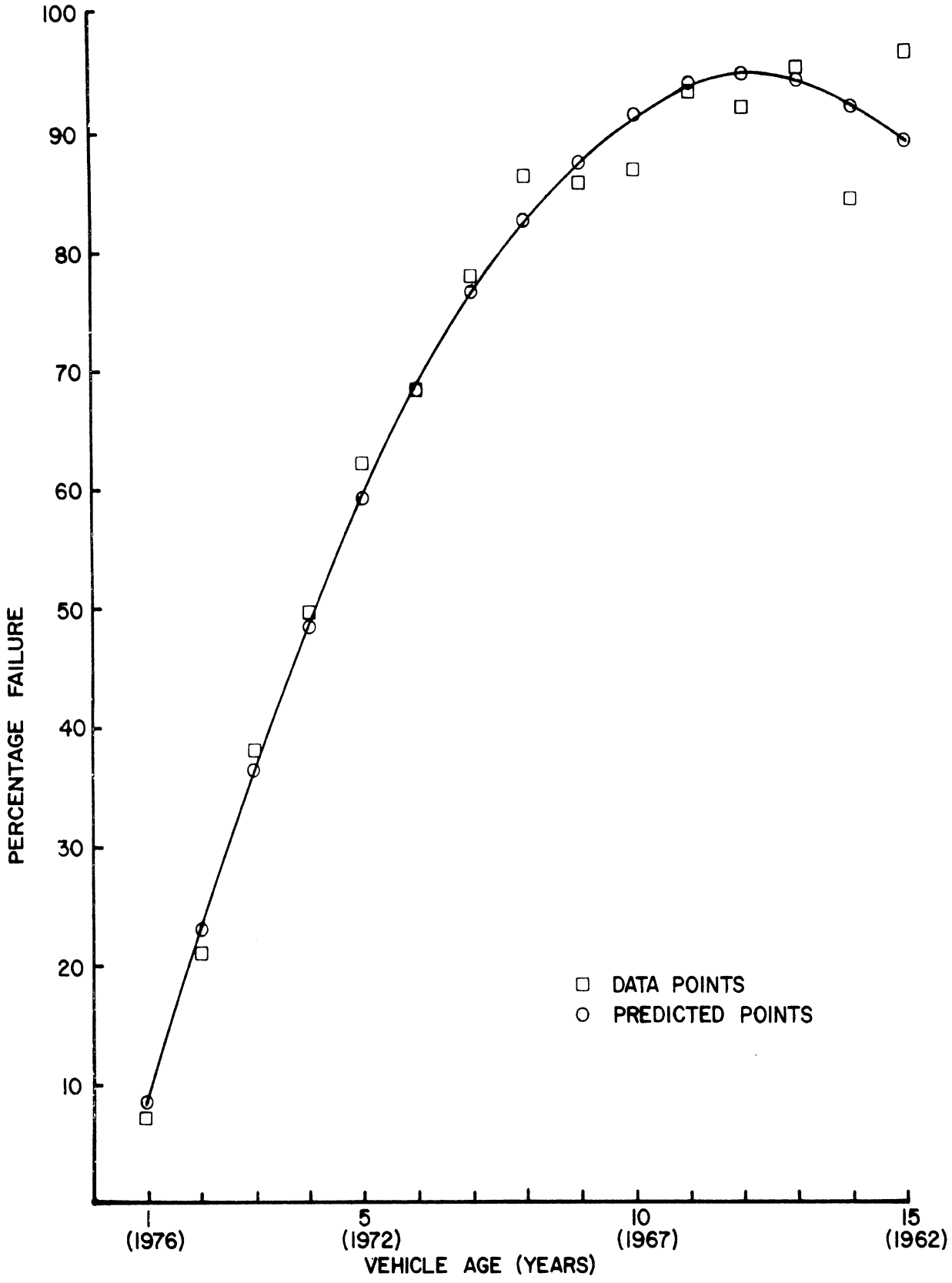


Figure 4.1. OBSERVED FAILURE RATES FOR TOTAL VEHICLE MODEL YEARS 1962-1976

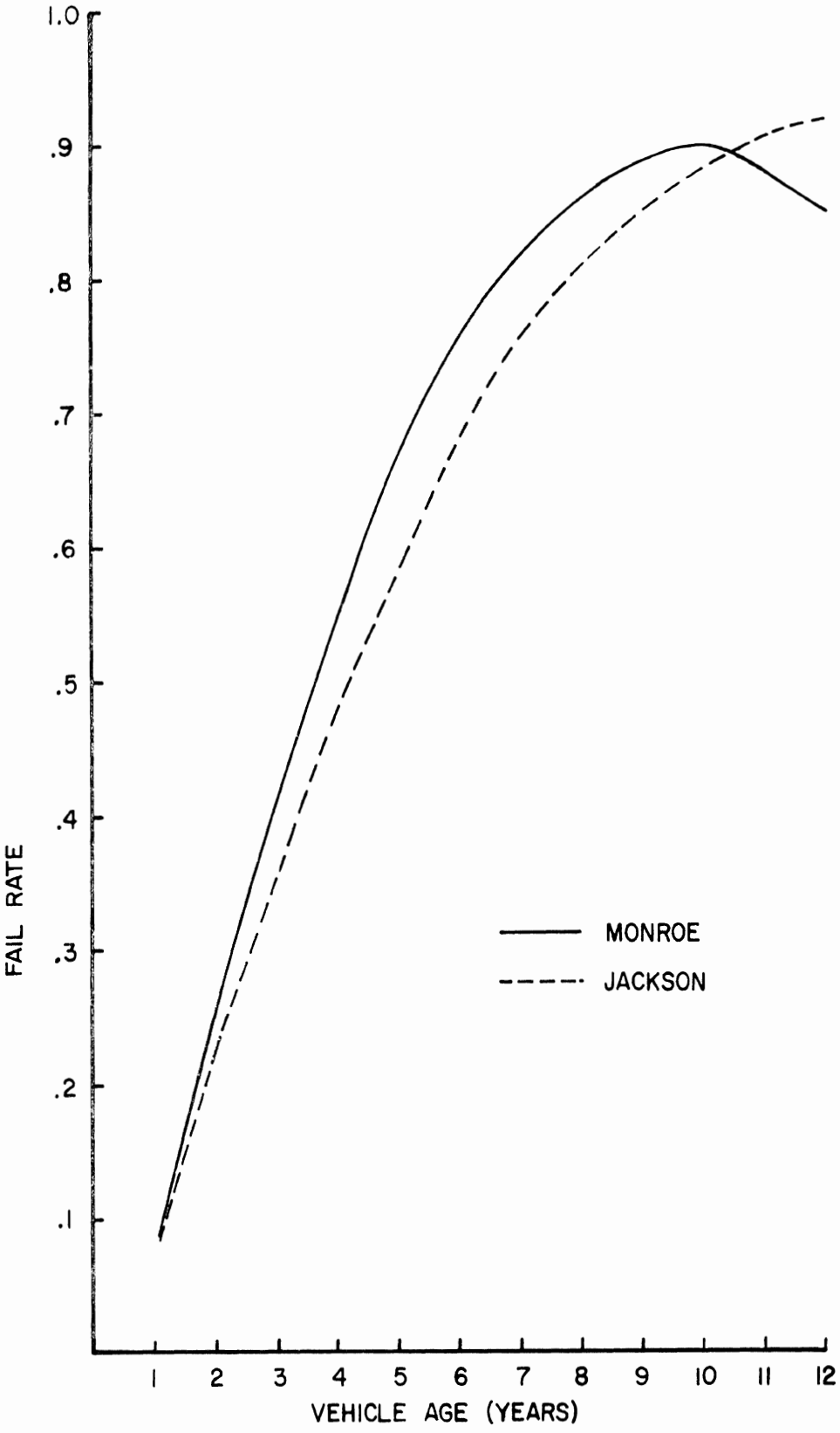


Figure 4.2. FITTED REGRESSIONS FOR FAIL RATE BY VEHICLE AGE FOR MONROE AND JACKSON COUNTIES

where X is the age in years and Y is the proportion of defective vehicles. For this model, R^2 = .993 which indicates that the model fits the data very well. As in 1975 there is a strong relationship between age and defect rate.

Regression analyses were performed with mileage as the predictor variable. These analyses showed mileage to do slightly better as a predictor of total vehicle failure than did vehicle age. However, as a guide to which vehicles should be inspected (for example, only vehicles older than 5 years), it is more practical to use age as a predictor variable. Analyses using mileage distributions are presented in Chapter 5.

Models were fit to the separate Monroe and Jackson County data to see if the relationship between age and failure rates was the same for both counties in 1976. Using data for vehicles aged 1 to 12+ years, the model for Monroe County is:

$$Y = -.129 + .212X - .011X^2$$
$$R^2 = .986$$

and for Jackson County the model is:

$$Y = -.096 + .174X - .007X^2$$
$$R^2 = .996$$

Figure 4.2 shows the trend lines. An F-test using the regression error Sum of Squares for the models was used to test whether the regressions for the two counties were the same. The test had a significance level of .018. Therefore there is some evidence that the regressions (i.e., the relationships between vehicle age and failure rate) are not the same in the two counties.

4.2.2 Specific Component Defects. Table C-8 in Appendix C gives the county and total sample results for the various tests on all the vehicles. The combined county age distributions of failure percentages for the newly

inspected vehicles are given in Figures C-1 to C-18. These figures are useful in pointing out linear trends in the failure rates of specific components. As in 1975, most component defect rates show an increase with age of the vehicle. Figures are not given for components which had failure rates of less than 5%.

Defects Relating to Vision. In the total sample only two vehicles were not fully equipped with safety glass. Overall, 4.4% of the vehicles had vision impaired due to a cracked or chipped windshield. Far more common vision imapirments were defective wipers and washers. Both of these component failure rates showed a strong tendency to increase with vehicle age. In the total sample, 76.5% of the vehicles had no vision defects, 18.5% had one defect, and 5.0% had two or more defects.

Lighting Defects. The data for lights in Table C-8 are self-explanatory. The light with the highest defect rate was the plate light, with 18.9% of the vehicles failing. The next most common failure was the headlight high beam. No vehicles had defective beam indicator lights. Overall, 88.9% of the vehicles had satisfactory headlights. The category "Major Light Defects" includes directional lights, stop and tail lights, high and low beam headlights, and headlight output. Only 76.1% of the vehicles had all major lights in satisfactory condition. Most of the light outage rates showed an increasing trend with age of the vehicle.

Exhaust Defects. The Figures for "Exhaust Noise" and "Total Exhaust" both show increasing defect rates with increasing vehicle age. There were very few vehicles that had excessive smoke in the exhaust (1.7%).

Control Defects. The stationary foot brake test is included in this category, along with steering, tire bulges or breaks, and tire tread. In this sample, 81.0% of the vehicles had no control defects and 1% had two or more defects. There were three tests in this group which had very low failure rates; the foot brake test, the steering test, and the check for tire bulges or cord breaks. The "Total Tire" failure rate shows a strong tendency to increase with vehicle age. Most of the control defects were worm tire tread.

Miscellaneous Defects. A large percentage (11.6%) of vehicles had defective parking brakes. Monroe County alone had a failure rate of 15%. This rate shows a tendency to increase with age for vehicles 1 to 10 years old, and is erratic for vehicles over ten years old.

All but 2.5% of the drivers had a proper operator license. A total of 2.7% of the drivers did not have all the proper credentials (license, registration and proof of insurance). As in 1975, these figures are probably not representative of the entire state since the vehicles sampled were not from the central city areas, nor from the extreme rural areas where compliance with registration and insurance laws is thought to be lower.

4.2.3 Brake Test Results. The moving-stopping test was conducted on all vehicles (except 15.8% who refused or were excused) in the same manner as was done in 1975. Tables C-9 to C-12 present the age distributions of the result variables for the moving-stopping test. The stopping test (Table C-10) showed that very few vehicles failed to stop adequately. Most of the stopping failures were due to side-to-side motion.

In the pedal pressure test most of the failures due to "Low Pedal," although "Low Pedal," "Soft Pedal," and "Pressure Loss" are all similar categories, and if combined the failure rate is 2.1%. All the moving-stopping test failure categories showed a trend which increased with vehicle age. An examination of the brake results distributed by age and by mileage failed to show any specific points in a vehicle's history (either in age or miles) where brake troubles start to increase in frequency.

4.3 Comparison with Other Inspection Data

In 1975 and 1976 the State Police conducted Operational Checklane inspections throughout Michigan. Since the vehicles inspected in these checklanes were not randomly selected for inspection, the failure rates should be higher than for randomly chosen vehicles. The table below gives the percentages of vehicles that passed the statewide inspections along with those that passed the random checklanes for this project.

	Statewide (Operational) 1975	Statewide (Operational) 1976	Project (Random) 1975	Project (Random) 1976
Vehicles Inspected	374,738	185,740	11,651	11,426
Percentage Passed	38.0%	37.0%	50.1%	44.0%

As expected, a higher percentage of the vehicles passed the random checklane inspection than passed the operational checklane in both study years. In this table it appears that the 1976 sample more closely resembles an operational checklane than did the 1975 sample. The above statewide data were reported in the State Police publication, "Michigan Traffic Accident Facts 1976".

The Michigan 1975 and 1976 random checklane failure rate data generally fall within the ranges quoted in the report Data on Vehicle Inspection Programs for State Appointed Stations, State Owned and Operated Stations (see Appendix E). The components for which the Michigan data disagree with the published data are tires (Michigan range: 14.4-19.7%; AAMVA range 0.4-7.2%), steering (Michigan: 0.2-0.4%; AAMVA: 1.5-9.1%), steering (Michigan: 0.2-0.4%; AAMVA: 1.5-9.1%), and headlights (Michigan: 8.4-11.8%; AAMVA: 13.9-42.0%). These differences could be due to many factors, including different inspection procedures and different laws about vehicles which must be inspected, or different penalties for failure to have the repairs done.

5.0 COMPARISONS AMONG THE STUDY GROUPS

Two major questions of this study were: (1) Would a 15% checklane inspection rate be more effective than a 5% checklane inspection rate in reducing outage rates among vehicle safety components? (2) How does a 15% checklane inspection compare with a periodic inspection program in reducing outage rates among vehicle safety components?

5.1 Effect of Increasing the Inspection Rate

Figure 5.1 illustrates the inspection results for cars in Monroe County. The proportion of vehicles which were found to have one or more defects in their equipment is related to the age of the vehicle. The two curves show the relationship between the failure to pass the inspection and the age of the vehicles for cars inspected in 1975 and for those inspected in 1976. Only slight differences are seen and the differences were not statistically significant at the 5% level. The curves were fit by the method of weighted least squares, described in Appendix F. Prior to the sample of vehicles taken in 1975, vehicles in Monroe County had been subject to the checklane inspection system at a (statewide) 5% rate. When the sample was taken in 1976, the vehicles had been subject to a checklane inspection at a 15% rate the previous year. The negligible difference in the two curves in Figure 5.1 indicates that there was no difference in the overall condition of the vehicles after increasing the rate of the checklane inspections. Thus the present data do not contradict the hypothesis that there was no change in the condition of vehicles in the general population due to the increased inspection efforts. If one takes the age distribution of cars in the State of Michigan as a standard population, then the outage rates may be summarized by an age-adjusted rate, which removes any differences caused by different ages of cars in the 1975 and 1976 samples. Using only cars up to and including ages of 12 years,

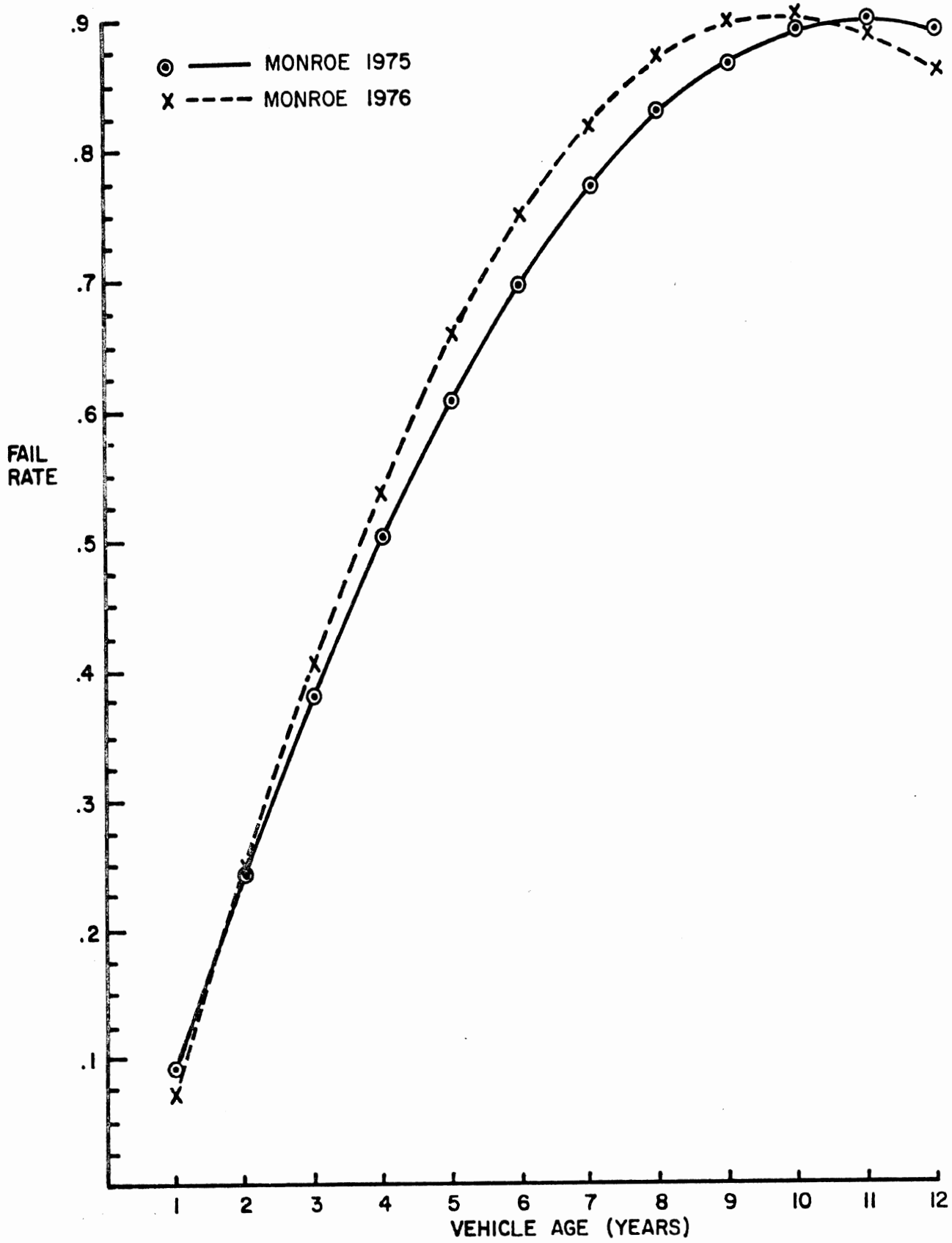


FIGURE 5-1. FITTED REGRESSIONS FOR FAILURE RATES BY VEHICLE AGE FOR THE 1975 AND 1976 MONROE COUNTY INSPECTIONS.

general population. This means further that the effect of the pseudo-periodic inspection is most appropriately measured within the group of reinspected vehicles. Direct comparisons of failure rates between the reinspected group and other groups are not appropriate. The reasons for the self-selection are not known. One might speculate that the cars which are owned by persons who plan to keep them longer are better maintained. Such cars would be more likely to be recaptured. Similarly, cars which have a low occurrence of mechanical problems are likely to be driven more and more likely remain with the same owner from one year to the next. These would also make the better cars more likely to appear in the reinspected group.

Figure 5-2 illustrates the overall inspection failure rate for the cars in the reinspected group (Jackson County). As before, the curves have been fitted by weighted least squares as described in Appendix F. The similarity of the curves is apparent. As before, the difference in the curves is not statistically significant at the 5% level. Thus, there is no evidence to suggest that the periodic inspection--as represented by the reinspected cars--improved the condition of the cars. If one standardizes the age distribution to that of the vehicles in the State of Michigan, restricting attention to the latest 12 model years, then the failure rate adjusted for age for cars in the reinspected group in 1975 is 46.9%, while in 1976 it is 45.6%. The difference is not significant. Even if it were, it appears to be too small to be of any practical importance.

A similar comparison can be made among the vehicles in Jackson County which were newly inspected each year. This group represents the set of vehicles which would only be influenced by the information campaign and the knowledge that some vehicles were being inspected in the checklanes. That is, the group represents the "spillover" effect of a checklane. None of these vehicles was previously inspected and required to correct any defects. The age-adjusted rates of inspection failures for newly inspected vehicles in Jackson County in 1975 was 54.7% and in 1976 it was 55.2%. Again the difference is not statistically significant and is of no practical importance.

the age adjusted rates for vehicles in 1975 (subject to a 5% inspection rate) is 55.6%, while that for vehicles in 1976 (subject to a 15% inspection rate) is 56.0% (Monroe County). This difference in the inspection failure rates, adjusted for age, is clearly negligible.

More detailed information on the failure rates by the age of the vehicle and by the specific vehicle component is presented in Appendix D. Most components show only small differences in failure rates among the two years and within a given age of car. It should be noted that the numbers of vehicles inspected which were older than ten years becomes rather samll. The number of cars of each age inspected each year is given in Table D-13.

The general answer to the first question seems to be that there is no evidence that an increased inspection rate changed the vehicle inspection failure rates.

5.2 Comparison of Periodic and Checklane Inspections

The second question is more difficult to answer. A direct comparison between the reinspected cars--representing a pseudo-periodic inspection group--and the newly inspected cars--representing a checklane population--was inappropriate. The reason for this was that the reinspected group proved to be a self-selecting sample. That is, the vehicles which were inspected both years form a special subgroup of the vehicles. This subgroup proved to be vehicles in better condition in 1975. Thus, they would be expected to remain in better condition in 1975. Table D-1 illustrates this effect. Note that in the table, an age by age comparison of the original 1975 failure rates of the recaptured (and thus reinspected) vehicles with the 1975 failure rates of the total Jackson County sample show that the recaptured vehicles were originally superior to the total sample in overall maintenance. This was not anticipated in the study design, and could not be detected until the analysis of the second years data was begun.

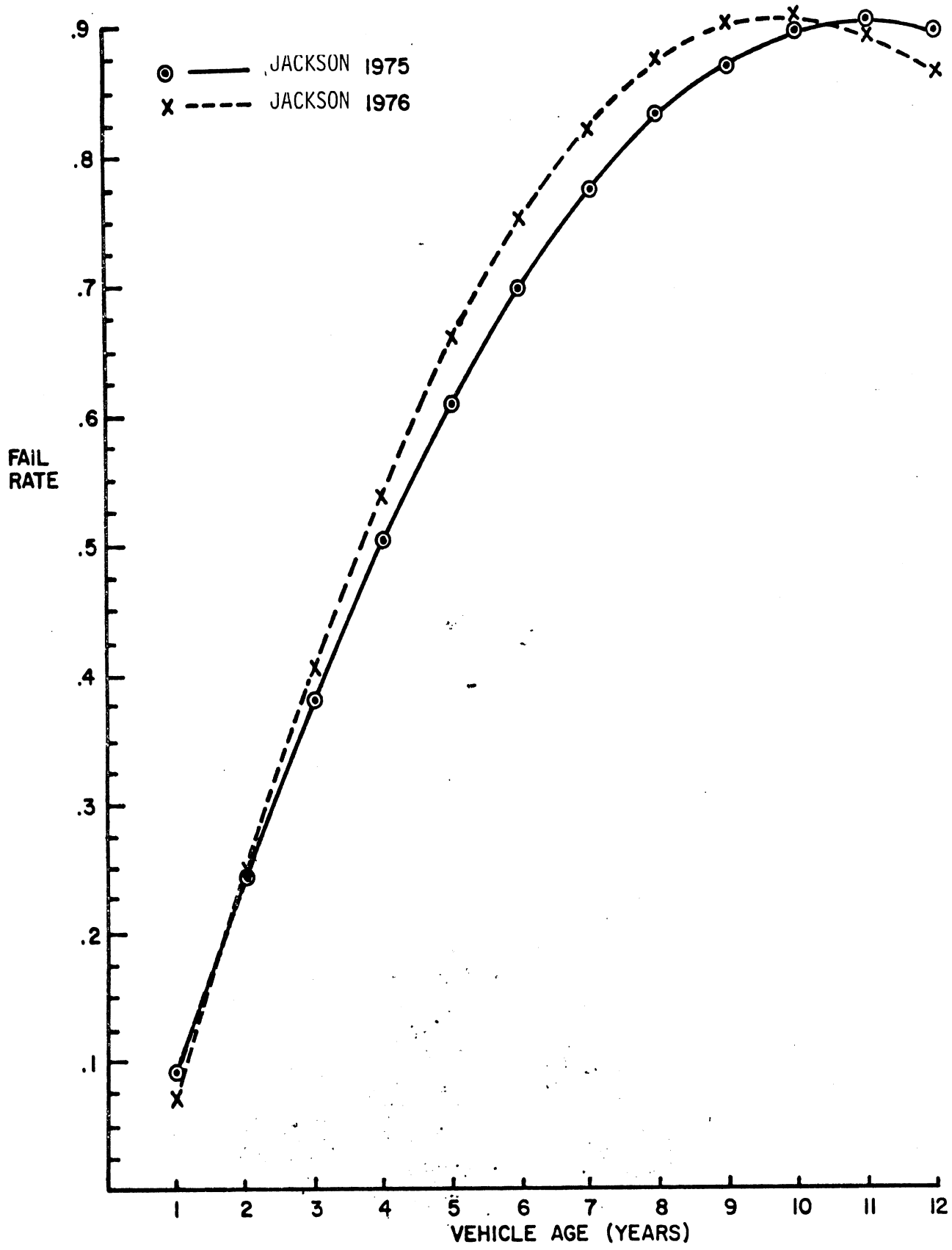


FIGURE 5-2. FITTED REGRESSIONS FOR FAILURE RATES BY VEHICLE AGE FOR THE 1975 AND 1976 JACKSON COUNTY INSPECTIONS.

Thus the general conclusion is that none of the groups showed reduction in the proportion of vehicles failing the inspection in 1976 as compared to the proportion failing in 1975. Thus, none of the inspection systems represented--periodic after one year, a 15% checklane, and vehicles not inspected but subjected to publicity campaigns about vehicle inspection and checklane inspections--showed a significant change in the proportion of vehicles failing the inspection.

5.3 Comparisons by Components

Tables D-1 through D-6 in Appendix D list failure rates in percent by vehicle age for the six major inspection categories (total vehicle, wiper & washers, headlights, total lights, total brakes, total tire) and Tables D-7 through D-12 do the same by vehicle mileage. Table D-13 gives the number of cars in each group, age, and year. Each table shows the data arranged by sample group and inspection year. Several observations stand out. First while total vehicle failure rates did not significantly change from 1975 to 1976 as discussed above, one major components' failure rates did change--total tire failure rates went up (see Table D-6). This represents a higher rate of insufficient tire tread as the specific defect. The reasons for this are not clear. There was a widely publicized rubber workers strike during the period, which may have affected tire availability or may have affected the tire replacement. Another possibility is that the inspection procedure in 1976 was more stringent than in 1975. In 1976, tread depth was measured, while in 1975 visual inspection for wear indicators was used. The same increased failure rate for tires is observed if vehicle mileage is used rather than vehicle age, so the effect is not due to cars of a given age having more miles in 1976 than in 1975. The tables show that the overall failure rates for all sample groups was higher in 1976 than in 1975. This increase in 1976 is due to an increase in the proportion of older cars in the 1976 sample. The increase in older cars can be seem by comparing the vehicle counts by age in Tables B-6 (1975) and C-5 (1976). This comparison shows, for example, that vehicles four years of age and older represent

58.1% of the 1975 sample but increase to 71% of the 1976 sample, and a strong relationship has already been demonstrated between vehicle age and vehicle failure rates. But other than age, the 1975 and 1976 samples are reasonably comparable. And if the defect rates are adjusted for the difference in age distributions, the resulting standardized rates are very similar. Figure 5-2 shows the original sample design with sample sizes and age-adjusted failure rates. Note that the difference in age distributions in the two years' samples together with the dependence of vehicle condition on age require that adjustments for age be included before any comparisons are made.

5.4 Estimated Repair Rates

Some additional information about the effectiveness of the inspection program in getting particular safety components repaired is available from the reinspected group. It must be born in mind that this is a self-selected group and that the estimates of the repair rates may thus be somewhat optimistic. Table 5-1 gives the proportion of the reinspected cars which passed the inspection both years on each specific component. The second column of the table gives the proportion of the cars which failed the inspection in 1976, given that they passed the inspection in 1975. This may be taken to be an estimate of the proportion of cars which would suffer a failure of that specific component during a year. Thus column two of Table 5-1 estimates an annual failure rate by components.

The third column of the table gives the proportion of the cars which passed the inspection in 1976, given that they had failed the inspection on that component in 1975. Clearly all these cars repaired the non-functioning component. As such, they represent one estimate of the repair rate for each specific component. However, if these cars were repaired shortly after the inspection in 1975, the component was subject to approximately one year of wear before the 1976 inspection, during which some of the new components might be expected to fail. As a result, this estimate of the repair rate may be somewhat too low. If one assumes that the failure rate for cars

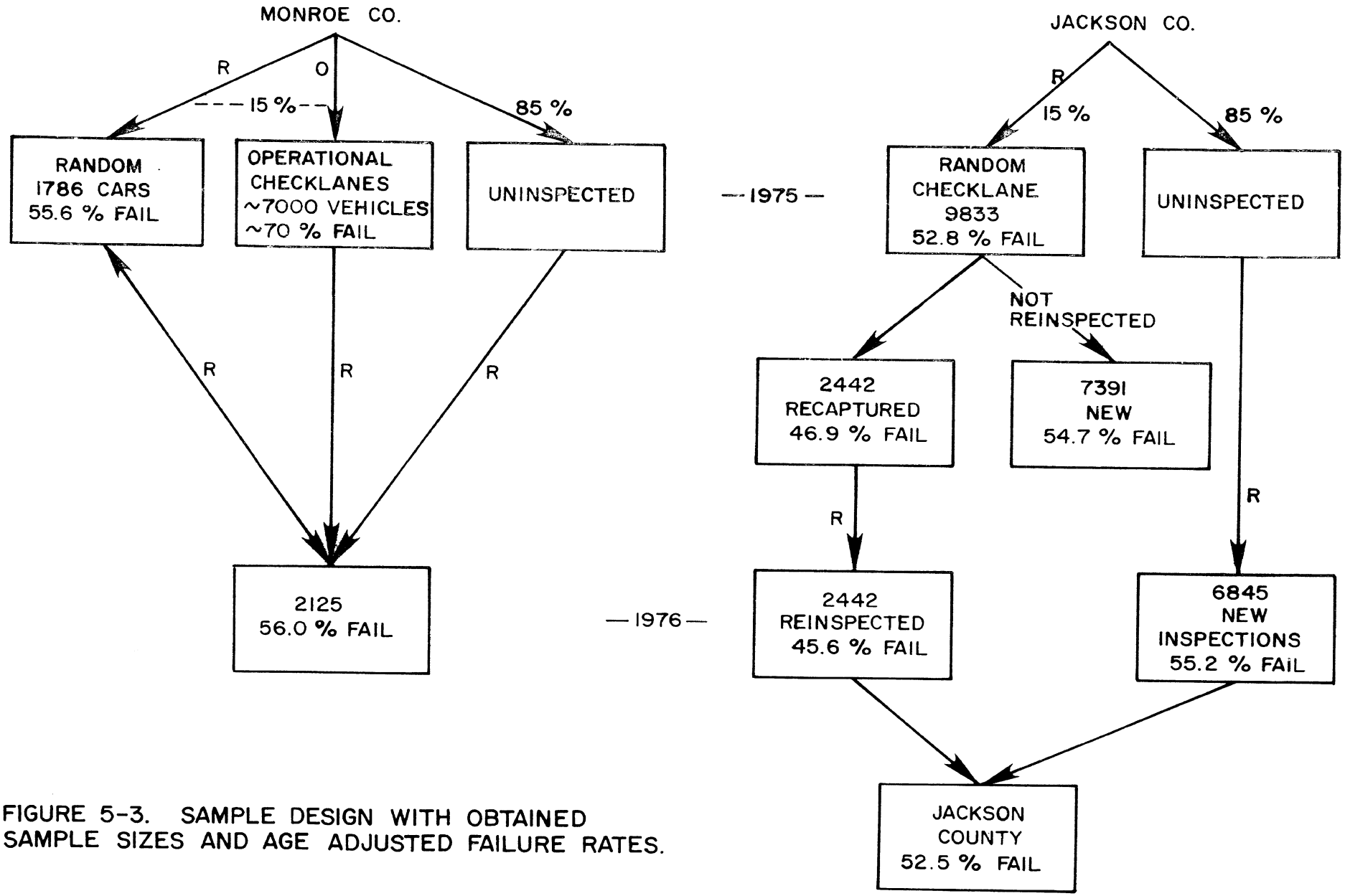


FIGURE 5-3. SAMPLE DESIGN WITH OBTAINED SAMPLE SIZES AND AGE ADJUSTED FAILURE RATES.

TABLE 5-1

REPAIR AND NEW FAILURE RATES FOR REINSPECTED VEHICLES

COMPONENT	PERCENT PASSING BOTH YEARS	PERCENT NEW FAILURES	PERCENT REPAIRED	ADJUSTED REPAIR RATE
WASHERS	81.8	8.9	79.4	87.2
WIPERS	78.8	10.1	76.2	84.8
FRONT T SIGNALS	94.2	3.2	88.1	91.0
REAR TURN SIGNALS	91.4	4.6	78.6	82.4
HEAD LTS	86.6	7.2	74.5	80.3
HIGH BMS	88.9	6.2	76.6	81.7
TAIL LTS	91.2	4.6	71.3	74.7
STOP LTS	90.3	4.3	74.8	78.2
LICENSE P.LT.	79.3	9.0	59.0	64.8
TIRE TD	80.0	13.1	71.5	82.3
PARKING BRAKE	90.9	4.3	68.0	75.3
MST-STOP	90.8	3.9	90.9	94.6
MST-PULL TO SIDE	96.0	3.3	87.6	90.6
MST-TOTAL	81.8	7.7	83.3	90.2
EXHAUST	86.6	8.4	51.5	56.2
ALL LTS	59.7	20.0	47.5	59.4
MAJ. MECH. TOTAL INSP	49.3	28.6	39.6	55.5
	41.6	32.4	34.5	51.0

which were repaired in response to the inspection in 1975 is the same as for those cars which passed the inspection in 1975, then an adjusted repair rate may be calculated reflecting that some components may have been repaired but may have failed again during the year. This adjusted repair rate is presented in the last column of Table 5-1.

Table 5-2 compares the return rates for the post cards issued to cars which did not pass the inspection in 1975 to the proportion of cars which passed the inspection in 1976. The comparison is made within five groups of cars--grouped by the number of defects found in the 1975 inspection. In general, the observed passing rate is lower than the percent of postcards returned. However, it must be noted that about one-third of the cars which passed in 1975 did not pass the inspection in 1976. Thus, the proportion of cars which passed in 1976 but not in 1975 is consistent with the reported return rate, if it is assumed that some cars were repaired but suffered an additional failure or a failure of a different component during the intervening year. The other obvious conclusion from Table 5-2 is that the repair rate decreases with the number of components which needed repair. This is evident not only in the postcard return rates, but also in the proportion of cars which passed in 1976, having failed in 1975.

Table 5-2

Passing Rates for Reinspected Vehicles
by Number of Defects in 1975

Number of Defects in 1975	Postcard Return Rate	Percent Passing in 1976	Estimated Repair Vehicle
0 (passed in 1975)	N.A.	67.6%	N.A.
1	57.7%	42.6%	64.6%
2	54.1%	30.2%	44.6%
3	49.2%	20.3%	30.1%
4+	41.4%	17.2%	25.5%

6.0 CONCLUSIONS AND RECOMMENDATIONS

The primary purposes of this study were to estimate the effect on the proportion of vehicles with outages in safety equipment of a 15% checklane inspection program and to compare this with the estimated effect of a simulated periodic (annual) motor vehicle inspection program. From the data collected the first year it became apparent that the safety component outage rates were strongly influenced by the age of the vehicle. As a result, comparisons among the groups of interest were adjusted for the ages of the vehicles involved. In addition to the conclusions relating to the two principal purposes of the study, some ancillary conclusions about the type of stopping test to be used, the relative outage rates of various components, and the repair rates are reported.

6.1 Effect of the 15% Checklane Inspection Program

The 15% random checklane operated in Monroe County. The crude proportion of cars failing the inspection in 1975 in Monroe County was 51.9% while in 1976 this rate climbed to 62%. However, the sample of cars obtained in 1976 was generally older than the sample obtained in 1975. The average difference in ages of cars was 0.9 years, or nearly one year. Comparing the individual outage rates for each age of car revealed that little difference in outage rates remained after age of car had been taken into account. The age distribution of cars in the State of Michigan (truncated at twelve years) was used as a standard population and the standardized rates of cars failing the inspection were calculated. The age-adjusted rate of failure of cars in 1975 in Monroe County was 55.6%. In 1976 the age-adjusted failure rate was 56.0%. Thus the rates of failures in Monroe

County remained essentially the same. This leads to the conclusion that the increase in the rate of inspection from a level of about 5% (statewide) to a level of 15% did not change the overall rate of failure of the inspection.

A similar experience was obtained in Jackson County. In Jackson County, the newly inspected vehicles in 1975 represent a sample from the approximately 5% random checklane inspection program. The newly inspected vehicles in 1976 represent a sample from a population subject to a 15% checklane inspection program, but with the re-inspected vehicles removed from the population. That is, the newly inspected vehicles in Jackson County in 1976 represent a sample from the vehicles which were not inspected the previous year. Thus, presumably they might be somewhat biased toward higher failure rates. The crude railure rates for Jackson County were 49.6% in 1975 and 57.9% in 1976 (for newly inspected vehicles). Again, most of the difference appears to be in the age of the vehicles. After adjusting for the different age distributions in the samples, the age-adjusted rates are 54.7% in 1975 and 55.2% in 1976, again indicating that no significant change has occurred. If one pools all the cars inspected in Jackson County, one should have a sample which is slightly biased toward fewer inspection failures, since it would include a higher percentage of the cars which were inspected in 1975 that would be due to chance. If this is done, the age-adjusted rates are 52.8% in 1975 and 52.5% in 1976. Again, no significant change is observed. The conclusion seems to be that the increase from a 5% to a 15% inspection rate has not influenced the overall failure rates.

The same pattern persisted when individual components were considered instead of the overall passing of failure of the entire vehicle. With few exceptions, the change from a 5% to 15% inspection rate failed to produce any changes in the outage rates of the vehicle population. Thus, no particular advantage can be claimed for the higher effort.

6.2 Effect of the Simulated PMVI

In Jackson County, a subsample of previously (in 1975) inspected vehicles was obtained during 1976. This subsample represents a simulated

PMVI group. The overall outage rate among these vehicles in 1976 was only 45.2%, apparently better than the other groups. However, this group turned out to be a self-selecting sample of the better and newer vehicles. The same cars were also better on the average than the other cars inspected in 1975. The overall failure rate in 1975 for this group of cars was only 38.5%. As a result, comparisons across groups appear to be invalid because of the self-selecting nature of the reinspected vehicles.

Comparisons within the reinspected vehicles can give insight into the effect of the PMVI as compared to the previous 5% checklane inspection program. Of course the reinspected cars are all (approximately) one year older than they were in 1975, so the age must be adjusted for. When the age-adjustment rates were calculated, the rate among this group in 1975 was found to be 46.9% and in 1976 it decreased slightly to 45.6%. Thus there was slight improvement in the overall failure rate. The difference was not statistically significant, however, giving a p-value of only 0.2, one-sided.

Comparisons by the specific components revealed essentially the same results: little change in the outage rates. There was one exception to the general pattern. Failure of the inspection because of insufficient tire tread was significantly higher in 1976 than in 1975. This persisted after the age of the vehicle was adjusted for. A similar adjustment, adjusting for the mileage of the vehicle also failed to remove the differences in the failure rates caused by insufficient tire tread. So there appeared to be a higher failure rate for insufficient in 1976 than in 1975. The other safety components showed slight--but non-significant--improvements. However, the worsening of the component tires balanced out the accumulated slight improvements in the other components to result in an overall insignificant change.

In conclusion, the simulated PMVI group did not experience a significant improvement rate in passing the inspection. Because of a previously unknown self-selection of the PMVI group, direct comparisons of outage rates with the checklane populations are not appropriate. Neither the simulated

PMVI group nor the checklane groups at the higher inspection rate showed an improvement over the operational checklane inspection program operating at approximately 5% of the vehicles. All of the random groups, however, exhibited a lower failure rate for the inspection than is reported from the operational checklanes. This may be interpreted to mean that the operational lanes the operational lanes are relatively successful in selecting vehicles from the traffic stream which are defective. In this sense, the operational checklanes seem to be rather effective at identifying the vehicles with mechanical defects.

6.3 Other Conclusions from the Study

Although in general no significant changes in the outage rates were found, one consistent exception was the condition of the tires. The level of tread on the tires was insufficient in a larger proportion of the cars inspected in 1976 than in 1975, even after adjustments for age and mileage were made. This was consistent in all groups. The adjusted rates were as follows. In the reinspected cars (simulated PMVI), the failure rate increased from 9.97% to 14.86%. In the newly inspected cars in Jackson County, the adjusted rate increased from 13.52% to 17.51%, and among the newly inspected cars in Monroe County the adjusted rate increased from 14.15% to 21.05%. Thus the data reflect a consistent worsening of the condition of the tires in the vehicle population. The reasons for are not known.

In general the adjusted rates for other components showed minor improvements, none of which were statistically significant or large enough to be of practical importance. The increased failure rate for tires more than balanced the minor gains in other components, resulting in no significant change in the overall rates. Had tires remained the same or shown a minor improvement, the overall rates of failure would have shown a slight improvement in all study groups--on the order of 4 or 5 percentage points. While this would probably have been statistically significant--that is, not due to chance--its practical significance is open to question.

A comparison of two types of braking tests--a moving stopping test (MST) and a wheel pull inspection (WPI)--was performed as part of the study. The

general conclusion was that the moving stopping test appeared to have advantages in terms of detecting vehicles which were deficient in current stopping capabilities, while the wheel pull inspection might be more diagnostic of future stopping difficulties. Although definite associations among components inspected in the WPI and performance measured in the MST were found, these were too weak to be used in a predictive sense. For example, although poor pedal pressure and low brake fluid levels were associated, the association was too weak to suggest that poor pedal pressure was due to low brake fluid levels.

The repair rates for components found inoperative among the reinspected vehicles were estimated. In most cases these were rather high--between eighty and ninety percent. One notable exception was the exhaust (noise) which had an estimated repair rate of only 56%. Another was the license plate light with a repair rate estimated at only 65%. Ability to stop (MST) was repaired at an estimated 95%. In general, the items which had low estimated repair rates tended to be the items perceived as minor by the motorists--or possibly in the case of exhaust noise as an item they did not wish to repair.

Neither the simulated PMVI nor the more intensive checklane inspection programs produced a significant reduction in the proportion of vehicles failing the inspection. As a result, continuation of the checklane inspection program at the current level of about 5% seems recommended.

Not surprisingly, defect rates were found to increase with the age of the vehicle. This adds credence to the contention that the operational checklane is highly efficient at detecting vehicles with safety defects.

Drivers with defective vehicles were issued a post card to return certifying that the repairs had been made within 21 days. A low rate of return--sixty percent--was observed. There was some indication that the return rate was lower for vehicles with several defects or with the more serious defects. Although the rate of return of the post cards may not completely reflect the rate of repair, it causes concern for the efficacy of this system for effecting repair of

defective vehicles. We would recommend that efforts to strengthen the repair incidence be considered.

The comparison of the moving stopping test with the wheel pull brake inspection indicated that the moving stopping test more accurately determines the car's braking capability. It is also quicker and easier to perform. For these reasons we recommend that it be adopted as the inspection procedure for braking capability.

Inferences from the driver interviews which were conducted only in 1975 are necessarily restricted to drivers in primarily local traffic. In particular, drivers on interstate roads and on long trips were excluded. Thus the results are not generalizable to the population of Michigan drivers.

Drivers generally thought that the 55 mph speed limit had reduced traffic fatalities and were opposed to raising the limit for all state highways. They were less opposed to increasing the speed limit on interstates and to instituting points for speeding violations in the 55 to 70 mph range.

Drivers in Jackson County showed a greater knowledge and awareness of the checklane inspection program than did those in Monroe County. This coincides with a more intensive information campaign there. It is recommended that public information campaigns be continued.

Two thirds of the drivers believe that seat belts save lives. However only 43 percent reported that they often or always wore seat belts. Only eleven percent of the drivers were observed to be wearing belts by the inspecting officers. This indicates that there may be a bias in the interview results. In the future, it is recommended that randomized response techniques be considered to reduce this potential bias.

APPENDIX A

DATA COLLECTION INSTRUMENTS

STATE OF MICHIGAN VEHICLE INSPECTION

127493

LOCATION

MONTH

DAY

MODEL YEAR

VEHICLE MAKE

VEH. TYPE — INTER. | COM. PACT | SPORT | CARRY ALL | JEEP TYPE | PANEL PICKUP | STR'T TRUCK | TRUCK TRACTOR | OTHER

Registration

Sticker No.

MILEAGE

PASS		REJECT
	GLASS — Safety	
	GLASS — Vision Impaired	
	WIPERS	
	WASHERS	
	LIGHTS — Front Direct.	
	LIGHTS — High Beam	
	LIGHTS — Low Beam	
	LIGHTS — Aim	
	LIGHTS — Output	
	LIGHTS — Tail	
	LIGHTS — Stop	
	LIGHTS — Rear Direct.	
	LIGHTS — Plate	
	LIGHTS — Beam Indicator	
	HORN	
	STEERING	
	BRAKES — Foot	
	BRAKES — Parking	
	TIRES — Bulges or Break	
	TIRES — Tread	
	EXHAUST — Noisy	
	EXHAUST — Smoke	
	MIRROR	
	SEAT BELTS (NOT REQ'D / NOT USED)	
PASS	TOTAL VEHICLE — SUMMONS — REJECT	

	SUMMONS
OPERATORS LICENSE — None	
OPERATORS LICENSE — Susp. or Revoked	
PASS — Other	
REGISTRATION — Improper	
PASS — None on Person	
INSURANCE — No Compliance	
PASS — None on Person	

1 2 3 4 TRIPS 5

PASS	SCHOOL BUS	REJECT
	Reflectors	
	Clearance Lights	
	Flashers	
	Fuel Tank	
	Defroster	
	Emergency Door	
	Fire Extinguisher	
	Flares/Warning Equipment	
	Color	
	Bumpers	
	Body Condition	
	Floor	
	Heater	
	First Aid Kit	
	Service Door	
	Steps	
	Seats	

Figure A-1

POLICE INSPECTION FORM

DEPT.

First Class
Permit No. 160
East Lansing,
Michigan
48823

PREPAID BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By:

DEPARTMENT OF STATE POLICE
VEHICLE INSPECTION UNIT
714 S. HARRISON ROAD
EAST LANSING, MICHIGAN 48823

Date | **MICHIGAN VEHICLE INSPECTION** | Dept

Veh. Make | Model Year | Reg. No

DEFECTS

- ☐ Safety glass
- ☐ Vision impaired
- ☐ Wipers
- ☐ Washers
- ☐ F. direct. lights
- ☐ High beams
- ☐ Low beams
- ☐ Aim
- ☐ Output
- ☐ Tail
- ☐ Stop
- ☐ R. direct. lights
- ☐ Plate light
- ☐ Horn
- ☐ Beam indicator
- ☐ Steering
- ☐ Tire bulge/break/tread
- ☐ OTHER
- ☐ Exhaust noise/smoke
- ☐ Mirrors
- ☐ Foot brake
- ☐ Parking brake

MICHIGAN STATE POLICE

Officer

Correct the above listed defect(s) within 21 days and mail this card as indicated on the reverse side. The results of your vehicle inspection have been entered into the Law Enforcement Information Network Computers and if you fail to make the needed repairs you are subject to detection and prosecution anytime this vehicle is stopped by a police-officer.

I hereby certify that the above listed defect(s) have been corrected

Signature of Driver or Owner

Figure A-2

Reply Postcard

Figure A-3

Brake Inspection Checklist

Sticker No._____ Inspector Initials_____

1. Brake type
   ( ) Disc ( ) Power
   ( ) Drum ( ) Non-power

2. Master cylinder fluid
   ( ) Full
   ( ) Half
   ( ) Low (slightly over the port)

3. Brake Fluid Contamination
   ( ) Pass
   ( ) Fail due to_____

4. Vacuum Hose
   ( ) Pass
   ( ) Fail

5. Wheel Bearing Grease
   ( ) Pass
   ( ) Fail (seal leaking)
   ( ) Unable to inspect

6. Wheel Pull
   ( ) Wheel pulled
   ( ) Unable to pull wheel (omit questions 7 through 10)

7. Drum Shoe Condition
   or
   Disc Pad Condition
   ( ) 75-100%
   ( ) 50-75%
   ( ) 1/32" - 50%
   ( ) Fail (less than 1/32")

8. Rotor or Drum
   ( ) Pass ( ) Worn (discolored)
   ( ) Cracked ( ) Grooves

9. Brake Hardware
   ( ) Pass ( ) Retainers
   ( ) Springs ( ) Self-adjuster

10. Wheel Cylinders
    ( ) Pass
    ( ) Fail (leaking)

11. Actual Tire Pressure
    LF_____ RF_____
    LR_____ RR_____

12. Tire Size_____

13. Recommended Tire Pressure
    LOADED_____
    UNLOADED_____

14. Comments (use reverse side if necessary)

THIS QUESTIONNAIRE IS BEING USED TO FIND OUT WHAT PEOPLE THINK ABOUT DIFFERENT AREAS RELATED TO VEHICLES IN MICHIGAN. YOUR ANSWERS WILL NOT AFFECT THE INSPECTION OF YOUR VEHICLE. THANK YOU!

Age:_____ Sex:_____ Sticker number:_____

THE FOLLOWING QUESTIONS ARE DESIGNED TO TEST YOUR KNOWLEDGE OF THE MICHIGAN VEHICLE INSPECTION PROGRAM. PLEASE CIRCLE THE NUMBER OF THE ANSWER WHICH IS THE MOST CORRECT.

1. To have your car inspected in Michigan, you must
   1. Do it yourself
   2. Take it to an authorized inspection station
   3. Allow the police to check it at any time
   4. Don't know

2. How often must you have your car inspected in Michigan?
   1. Never
   2. Every 6 months
   3. Every year
   4. When requested by police
   5. Don't know

3. Where did you first hear of the Michigan Vehicle Inspection Program?
   1. Friends
   2. Newspapers, radio, television
   3. Service station or garage
   4. Police
   5. Don't remember
   6. Didn't hear of it

4. When did you first hear of the Michigan Vehicle Inspection Program?
   1. Today
   2. Sometime in the past

5. About how far are you away from home right now?
   1. Less than 1 mile
   2. One to 2 miles
   3. Two to 5 miles
   4. Five to 10 miles
   5. More than 10 miles and a resident of this county
   6. More than 10 miles but not a resident of this county

6. How often do you wear seatbelts when driving or riding in a car?
   1. Always
   2. Often
   3. Seldom
   4. Never

7. When wearing seatbelts, do you feel?
   1. Greatly inconvenienced
   2. Somewhat inconvenienced
   3. Not inconvenienced

THE FOLLOWING STATEMENTS REQUEST YOUR OPINION. PLEASE CIRCLE THAT OPINION WHICH BEST EXPRESSES YOUR OWN.

8. Seatbelts save lives.
   1. Agree
   2. Disagree
   3. No opinion

9. The 55 mph speed limit reduces highway fatalities.
   1. Agree
   2. Disagree
   3. No opinion

10. A higher speed limit should be reinstated on interstate highways.
    1. Agree
    2. Disagree
    3. No opinion

11. Higher speed limits should be reinstated on all state highways.
    1. Agree
    2. Disagree
    3. No opinion

12. Points should be given on a driver's license for speeding violations between 55 and 70 miles per hour.
    1. Agree
    2. Disagree
    3. No opinion

CP_____ IN_____

Figure A-4

Driver Interview

Table A-1

LOCATION CODES

Monroe County

4810	Stewart Road Church of God Stewart Road between US-24 and M-125
4820	Route M-50 Near Raisinville Rd. west of Monroe
4830	First Baptist Church Corner of Lewis Rd. and Erie Rd. North of Temperance
4840	Route US-24 On US-24 south of Mich. State Police post

Jackson County

4910	Springport Road West of Campbell, Blackman Twp.
4915	Airport Lanes Airport Rd. across from airport, Blackman Twp.
4920	Ann Arbor Road (BR 94) East of Sutton, Leoni Twp.
4921	Wisener Street Back of Shopping plaza, north of city of Jackson
4922	Monroe Street Between Wisener St. and West St.
4930	Ramp from M-50 to US-127 From Westbound M-50 to Northbound US-127, Summitt twp.
4935	Moose Lodge Lansing Ave. at the Moose Lodge, city of Jackson
4940	Route M-60 Between I-94 and McCain Rd., eastbound, Summitt twp.
4945	Route M-50 Southbound, city of Jackson
4950	Route M-106 At Bunkerhill Rd., Henrietta twp.
4955	US-127 East service drive of US-127 at Weatherby Rd., Columbia

Table A-1 Continued

4960	Parnall School Lansing Ave. north of Parnall St., Blackman twp.
4965	Lumen Christi High School Spring Arbor Rd. at L.C.H.S., Summitt twp.
4970	McDevitt Road West of US-127, Summitt twp.
4975	Parma Baptist Church Michigan Ave. east of Parma at church, Sandstone twp.
4980	Route M-50 North of McDevitt Rd., Summitt twp.
4985	Ferguson Road At the intersection of Ferguson, Horton, and Jackson Rds. Summitt twp.
4990	Elm Road North of I-94, Blackman twp.
4995	Jackson State Prison North of city of Jackson

Table A-2

Checklane Inspection Schedule

Monroe County-1975

DATE	LOC.	INSP.	TOTAL	WHEEL PULL	TOTAL
7-1-75	4810	177	177	0	0
7-2-75	4820	208	385	50	50
7-03-75	4830	185	570	0	50
7-07-75	4820	197	767	51	101
7-08-75	4830	177	944	41	142
7-09-75		000	944	00	142
7-10-75	4810	186	1130	49	191
7-11-75	4840	187	1317	19	210
7-14-75	4810	194	1511	41	251
7-15-75	4820	107	1618	23	274
7-16-75	4840	175	1793	29	303
7-17-75	4810	120	1913	30	333
7-18-75	4820	106	2019	0	333

Monroe County-1976

DATE	LOC.	INSP.	TOTAL
5-4-76	4830	150	150
5-5-76	4840	90	240
5-7-76	4820	130	370
5-10-17	4810	130	500
5-11-76	4840	110	610
5-12-76	4850	100	710
5-13-76	4860	150	860
5-14-76	4810	140	1000
5-17-76	4870	88	1088
5-18-76	4830	115	1203
5-19-76	4820	125	1328
5-20-76	4840	62	1390
5-21-76	4850	100	1490
5/24	4860	160	1650
5/25	4810	130	1780
5/26	4820	145	1925
5/27	4850	145	2070
5/28	4860	130	2200

Table A-2 Continued

Jackson County - 1975

DATE	LOC.	INSP.	TOTAL	WHEEL PULL	TOTAL
7-21-75	4910	197	197	22	22
7-22-75	4920	191	388	39	61
7-23-75	4930	215	603	43	104
7-24-75	4940	203	806	48	152
7-25-75	4950	120	926	38	190
7-28-75	4955	184	1110	48	238
7-29-75	4960	221	1331	54	292
7-30-75		000	1331	00	292
7-31-75	4910	203	1534	42	334
8-01-75	4920	150	1684	40	374
8-04-75	4930	210	1894	43	417
8-05-75	4940	83	1977	19	436
8-06-75	4965	202	2179	43	479
8-07-75	4955	185	2364	40	519
8-08-75	4960	92	2456	30	549
8-11-75	4965	221	2677	56	605
8-12-75	4975	222	2829	50	655
8-13-75	4920	100	2929	28	683
8-14-75	4930	160	3089	53	736
8-15-75		0	3089	0	736
8-18-75	4950	160	3249	40	776
8-19-75	4955	136	3385	40	816
8-20-75	4960	190	3575	45	861
8-21-75	4965	220	3795	52	913
8-22-75	4920	53	3848	16	929
8-25-75	4930	222	4070	51	980
8-26-75		0	4070	0	980
8-27-75	4955	213	4283	50	1030
8-28-75	4965	208	4491	49	1079
8-29-75	4970	116	4607	27	1106
9-01-75		0	4607	0	1106
9-02-75	4980	106	4713	18	1124
9-03-75	4985	200	4913	40	1164
9-04-75	4990	232	5145	42	1206
9-05-75	4920	28	5173	9	1215
9-08-75	4970	227	5400	45	1260
9-09-75	4975	211	5611	57	1317
9-10-75	4980	236	5847	44	1361
9-11-75	4985	213	6060	34	1395
9-12-75		0	6060	0	1395

Table A-2 Continued

Jackson County - 1975

DATE	LOC.	INSP.	TOTAL	WHEEL PULL TOTAL	
9-15-75	4930	226	6268	38	1433
9-16-75	4970	228	6514	41	1474
9-17-75	4975	190	6704	39	1513
9-18-75	4990	56	6760	13	1524
9-19-75	4985	49	6809	13	1537
9-22-75	4990	148	6957	33	1570
9-23-75	4940	176	7133	41	1611
9-24-75	4955	157	7290	40	1651
9-25-75	4965	108	7398	31	1682
9-26-75	4920	66	7464	18	1700
9-29-75	4950	238	7702	35	1735
9-30-75	4940	252	7954	45	1780
10-01-75	4985	188	8142	30	1810
10-02-75	4955	199	8341	32	1842
10-03-75	4965	141	8482	38	1880
10-06-75	4922	224	8706	37	1917
10-07-75	4945	228	8934	40	1957
10-08-75	4915	297	9231	47	2004
10-09-75	4921	201	9432	31	2035
10-10-75	4995	156	9588	29	2064
10-13-75	4940	241	9829	34	2098
10-14-75	4935	209	10038	35	2133
10-15-75	4955	150	10188	40	2173
10-16-75	4965	150	10338	30	2203
10-17-75	4985	0	10338	0	2203

Table A-2 Continued

JACKSON COUNTY 1976

DATE	LOCATION	STICKERS	TOTAL	NON-STICKERS	TOTAL
6-1-76	4915	70	70	146	146
6-2-76	4920	34	104	164	310
6-3-76	4921	96	200	98	408
6-4-76	4910	15	215	121	529
6-7-76	4922	51	266	146	675
6-8-76	4930	51	317	151	726
6-9-76	4940	66	383	132	958
6-10-76	4945	61	444	114	1072
6-11-76	4950	18	462	162	1234
6-14-76	4955	46	508	102	1336
6-15-76	4960	84	592	99	1435
6-16-76	4965	104	696	91	1526
6-17-76	4970	87	783	86	1612
6-18-76	4975	46	829	126	1738
6-21-76	4980	53	882	151	1889
6-22-76	4985	57	939	115	2004
6-23-76	4990	69	1008	74	2078
6-24-76	4910	13	1021	16	2094
6-25-76	4915	39	1060	124	2218
6-28-76	4920	21	1081	152	2370
6-29-76	4921	41	1122	115	2370
6-30-76	4930	19	1141	78	2563
7-1-76	4940	41	1182	133	2696
7-2-76	4945	39	1221	66	2762
7-6-76	4955	37	1258	99	2861
7-8-76	4965	59	1317	83	2944
7-9-76	4970	63	1380	84	3028
7-12-76	4975	19	1399	116	3144
7-13-76	4930	36	1435	125	3269
7-14-76	4985	43	1478	104	3373
7-15-76	4990	37	1515	102	3475
7-16-76	4910	32	1547	99	3574
7-19-76	4915	50	1597	157	3731
7-20-76	4920	28	1625	135	3866
7-21-76	4922	18	1643	100	3966
7-22-76	4980	46	1689	86	4052
7-23-76	4940	57	1746	106	4158

Table A-2 Continued

JACKSON COUNTY 1976

DATE	LOCATION	STICKERS	TOTAL	NON-STICKERS	TOTAL
7-26-76	4960	69	1815	141	4299
7-27-76	4955	35	1850	127	4426
7-28-76	4950	8	1858	90	4516
7-29-76	4965	2	1860	4	4520
7-30-76	4965	41	1901	92	4612
8-2-76	4940	26	1927	176	4788
8-3-76	4955	43	1970	114	4902
8-4-76	4960	36	2006	156	5058
8-5-76	4965	41	2047	115	5173
8-6-76	4930	37	2084	132	5305
8-9-76	4975	27	2111	120	5425
8-10-76	4920	14	2125	98	5523
8-11-76	4922	42	2167	88	5611
8-13-76	4940	19	2186	98	5709
8-16-76	4985	25	2211	121	5830
8-17-76	4955	21	2232	114	5944
8-18-76	4960	31	2263	106	6050
8-20-76	4945	41	2304	101	6151
8-23-76	4990	27	2331	127	6278
8-24-76	4921	26	2357	131	6409
8-25-76	4922	14	2371	114	6523
8-26-76	4945	37	2408	102	6625
8-27-76	4965	24	2432	118	6743
8-31-76	4970	37	2469	87	6830
9-1-76	4940	17	2486	95	6925
9-2-76	4985	33	2519	103	7028

Table A-3

Checklane Variable List

Variable Number	Variable Name	Original Location	New Location	Recode Notes
1	Sticker Number	16-21	1-6	
2	Location Code	1-5	7-11	
3	Month of Checklane	7-8	12-13	
4	Day of Checklane	9-10	14-15	
5	Year of Checklane	11-12	16-17	
6	Julian Date	----	18-22	
7	Vehicle Year	13-14	23-24	
8	Vehicle Type	15	25	note 1
9	Vehicle Make	22-23	26-27	note 2
10	Vehicle Mileage	24-26	28-30	
11	Number of Trips	30	31	
12	Safety Glass	31-32	32	note 3
13	Vision Impaired	33-34	33	note 3
14	Total Glass	35-36	34	note 3
15	Wipers	37-38	35	note 3
16	Washers	39-40	36	note 3
17	Total Wipers and Washers	41-42	37	note 3
18	Mirror	107-108	38	note 3
19	Vision Defects	-----	39	note 4
20	Front Directional Lights	43-44	40	note 3
21	High Beams	45-46	41	note 3
22	Low Beams	47-48	42	note 3
23	Headlight Aim	49-50	43	note 3
24	Headlight Output	51-52	44	note 3
25	Headlights Operation	-----	45	note 5
26	Tail-lights	53-54	46	note 3
27	Stop lights	55-56	47	note 3
28	Rear directional	57-58	48	note 3
29	Plate light	59-60	49	note 3
30	Beam indicator light	61-62	50	note 3

Table A-3 Continued

31	Total lights	63-64	51	note 3
32	Major light defects	-----	52	note 6
33	Total Light Defects	-----	53	note 7
34	Horn	65-66	54	note 3
35	Steering	67-68	55	note 3
36	Foot Brake	69-70	56	note 3
37	Parking Brake	71-72	57	note 3
38	Total Brake	73-74	58	note 3
39	Tire Bulges or Break	75-76	59	note 3
40	Tire Tread	77-78	60	note 3
41	Total Tires	79-80	61	note 3
42	Control Defects	-----	62	note 8
43	Exhaust Noise	81-82	63	note 3
44	Exhaust Smoke	83-84	64	note 3
45	Total Exhaust	85-86	65	note 3
46	Operators License	87-94	66	note 9
47	Vehicle Registration	95-100	67	note 10
48	Vehicle Insurance	101-106	68	note 11
49	Operator Defective	-----	69	note 12
50	Major Mechanical Defect	-----	70-71	note 13
51	Total Mechanical Defect	-----	72-73	note 14
52	Total Vehicle	109-110	74	note 3
53	Summons Issued	111-112	75-76	note 15
54	Seat Belts	113-114	77	note 3
55	Brake Light	115	78	note 16
56	Wheel Pull	116	79	note 17
57	Pedal Pressure Test	117	80	note 18
58	Stopping Test	118	81	note 19
59	Stopping Audible	119	82	note 20
60	Total Stopping Defects	-----	83	note 21
61	Total Inspection Defects	-----	84-85	note 22

Table A-3 Continued

62	Brake Key	----	86	note 23
63	Interview Key	----	87	note 23
64	Sticker Number	1-7	88-94	
65	Inspector Initials	8-9	95-96	note 24
66	Brake Type	10-11	97-98	note 25
67	Master Cylinder Fluid	12	99	note 26
68	Brake Fluid Quality	13	100	note 27
69	Vacuum Hose	14	101	note 27
70	Wheel Bearing Grease	15	102	note 28
71	Wheel Pull	16	103	note 29
72	Shoe-Pad Condition	17	104	note 30
73	Rotor or Drum	18	105	note 31
74	Brake Hardware	19	106	note 32
75	Wheel Cylinders	20	107	note 27
76	L-F Tire Pressure	21-22	108-109	
77	L-R Tire Pressure	23-24	110-111	
78	R-F Tire Pressure	25-26	112-113	
79	R-R Tire Pressure	27-28	114-115	
80	Tire Size	29-38	116-125	
81	Front Loaded Rec. Press.	39-40	126-127	
82	Rear Loaded Rec. Press.	41-42	128-129	
83	Front Unloaded Rec. Press.	43-44	130-131	
84	Rear Unloaded Rec. Press.	45-46	132-133	
85	Comments	47	134	note 33
86	Sticker Number	1-7	135-141	
87	Age of Driver	8-9	142-143	
88	Sex of Driver	10	144	note 34
89	Question 1	11	145	note 35
90	Question 2	12	146	note 35
91	Question 3	13	147	note 35
92	Question 4	14	148	note 35

Table A-3 Continued

93	Question 5	15	149	note 35
94	Question 6	16	150	note 35
95	Question 7	17	151	note 35
96	Question 8	18	152	note 35
97	Question 9	19	153	note 35
98	Question 10	20	154	note 35
99	Question 11	21	155	note 35
100	Question 12	22	156	note 35
101	Completion Problems	23	157	note 36
102	Interviewer Initials	24-25	158-159	note 24
103	Match Key		160	note 37
104	Sticker Number		161-166	
105	Location Code		167-171	
106	Month of Checklane		172-173	
107	Day of Checklane		174-175	
108	Year of Checklane		176-177	
109	Julian Date		178-182	
110	Vehicle Year		183-184	
111	Vehicle Type		185	note 1
112	Vehicle Make		186-187	note 2
113	Vehicle Mileage		188-190	
114	Number of Trips		191	
115	Safety Glass		192	note 3
116	Vision Impaired		193	note 3
117	Total Glass		194	note 3
118	Wipers		195	note 3
119	Washers		196	note 3
120	Total Wipers and Washers		197	note 3
121	Mirror		198	note 3
122	Vision Defects		199	note 4
123	Front Directional Lights		200	note 3
124	High Beams		201	note 3
125	Low Beams		202	note 3

Table A-3 Continued

126	Headlight Aim	203	note 3
127	Headlight Output	204	note 3
128	Headlight Operation	205	note 5
129	Tail Lights	206	note 3
130	Stop Lights	207	note 3
131	Rear Directional	208	note 3
132	Plate Light	209	note 3
133	Beam Indicator Light	210	note 3
134	Total Lights	211	note 3
135	Major Light Defects	212	note 6
136	Total Light Defects	213	note 7
137	Horn	214	note 3
138	Steering	215	note 3
139	Foot Brake	216	note 3
140	Parking Brake	217	note 3
141	Total Brake	218	note 3
142	Tire Bulges or Break	219	note 3
143	Tire Tread	220	note 3
144	Total Tires	221	note 3
145	Control Defects	222	note 8
146	Exhaust Noise	223	note 3
147	Exhaust Smoke	224	note 3
148	Total Exhaust	225	note 3
149	Operators License	226	note 9
150	Vehicle Registration	227	note 10
151	Vehicle Insurance	228	note 11
152	Operator Defective	229	note 12
153	Major Mechanical Defects	230-231	note 13
154	Total Mechanical Defects	232-233	note 14
155	Total Vehicle	234	note 3
156	Summons Issued	235-236	note 15
157	Seat Belts	237	note 3
158	Brake Light	238	note 16

Table A-3 Continued

159	Recheck	239	note 38
160	Pedal Pressure Test	240	note 18
161	Stopping Test	241	note 19
162	Stopping Audible	242	note 20
163	Total Stopping Defects	243	note 21
164	Total Inspection Defects	244-245	note 22

Checklane Recode Notes

1. V8 - Vehicle type

Orig. Value	Type	New Value
0	Full Size	9
1	Intermediate	1
2	Compact	2
3	Sports Car	3
4	Station Bus, Carryall	4
5	Jeep	5
6	Pickup or panel	6
7	Unit or straight tractor	7
8	Truck tractor (semi)	8
other	Unknown/missing	0

2. V9 = Vehicle Make

Orig. Value	New Value
01--14	01--14
18--31	18--31
39--47	39--47
00	50
other	00

3.

Orig. Value	Code	New Value
01	Fail	2
10	Pass	1
Other	Missing	0

4. V19= # visor defects plus 1

set to zero
scan (V12, V13, V15, V16, V18)
Count number of "2" and add 1

5. V25 = headlight operation

set to zero
scan (V21, V22, V24)
if all = "1" V25 = 1
if any = "2" V25 = 2

6. V32 = # major light defects plus 1

```
set to zero
scan (V20, V21, V22, V24, V26, V27, V28)
count number of "2" and add 1
```

7. V33 = # light defects plus 1

```
set to zero
scan (V23, 29, 30)
count number of "2"
Add V32
```

8. V42 = # control defects plus 1

```
set to zero
scan (V35, V36, V39, V40)
count number of "2" and add 1
```

9. V46 = operators license

```
set V46 and K1 to zero
if positions 93-94 equal "10" then V46=1 (pass)
If positions 87-88 equal "01" then V46=2 (no license
   and K1=K1 + 1
if positions 89-90 equal "01" then V46 = 3
   (suspended or revoked) and K1=V1+1
if positions 91-92 equal "01" then V46=4 (other)
   and K1=K1+1
if K1 is greater than 1 V46 = 5
```

10. V47 = vehicle registration

```
set to zero
if positions 99-100 equal "10" V47 = 1 (pass)
if positions 95-96 equal "01" V47 = 2 (improper)
if positions 97-98 equal "01" V47 = 3 (none on person)
```

11. V48 = vehicle insurance

```
set to zero
if positions 105-106 equal "10" V48 = 1 (pass)
if positions 101-102 equal "01" V48 = 2 (no compliance)
if positions 103-104 equal "01" V48 = 3 (none on person)
```

Table A-3 Continued

12. V49 = Operator defective

set to two
if V46, V47, V48 are all equal "1" then V49 = 1

13. V50 = major mechanical defects plus 1

add V19, V32, V42
subtract two
if V43 equals "2" then V50 = V50 + 1
if V44 equals "2" then V50 = V50 + 1

14. V51 = total mechanical defects plus 1

add V19, V33, V42
subtract two
if V43 = "2" then V51 = V51 + 1
if V44 = "2" then V51 = V51 + 1
if V34 = "2" then V51 = V51 + 1

15. V53 = # summons issued plus 1

add 1 to positions 111-112
if V53 is greater than 90 or less than 0, set V53 to 0

16. V55 = Brake light

set to zero

Old Value	Code	New Value
0	Pass	3
1	Fail	1
2	Not checked	2

17. V56 = Wheel pull

set to zero

Old Value	Code	New Value
0	Yes	2
1	No	1

18. V57 = Pedal Pressure Test

set to zero

Old Value	Code	New Value
0	Pass	7
1	Soft Pedal	1
2	Low Pedal	2
3	Pressure Loss	3
4	Complete Loss	4
5	Hard Pedal	5
6	Pulsating Pedal	6

19. V58 = Stopping Test

set to zero

Old Value	Code	New Value
0	Pass	4
1	Cannot Stop	1
2	Side to Side	2
3	Both 1 and 2	3

20. V59 = Stopping audible

Set to zero

Old Value	Code	New Value
0	Pass	2
1	Fail	1

21. V60 = total stopping defects plus 1

Set V60 to 1
if V57 not equal to "7" add 1 to V60
if V58 not equal to "4" add 1 to V60
if V59 not equal to "2" add 1 to V60
if V57=0 or V58=0 or V59=0 set V60 to 0

22. V61 = total inspection defects plus 1

if V60=0 set V61 = V51
if V60 not equal to zero, then V61=V60+V51-1

Table A-3 Continued

23. Code Values

0 = no data available
1 = data

24. Code values:

01 = R. Alexa
02 = R. Copp
03 = R. Corn
04 = R. Crombez
05 = D. Hindal
06 = M. Huber
07 = J.P. Monson
08 = M. Sackett
09 = M. Todd
00 = Other or missing

25. Code Values:

00 = missing
11 = power disc
12 = non-power disc
21 = power drum
22 = non-power drum

26. Code values:

0 = missing
1 = full
2 = half
3 = low

27. Code values:

0 = missing
1 = pass
2 = fail

28. Code values:

0 = missing
1 = pass
2 = fail
3 = unable to inspect

29. Code values:

0 = missing
1 = wheel pulled
2 = unable to pull

30. Code values:

0 = missing
1 = 75-100%
2 = 50-75%
3 = 1/32"=50%
4 = Fail

31. Code Values:

0 = missing
1 = pass
2 = cracked
3 = worn
4 = grooves

Table A-3 Continued

32. Code values:

0 = missing
1 = pass
2 = springs
3 = retainers
4 = self-adjuster

33. Code Values:

1 = no comment
2 = comment

34. Code values:

0 = missing
1 = male
2 = female

35. Refer to questionnaire for code values

0 = missing

36. Code values:

1 = none
2 = refused
3 = illiterate
4 = no reading glasses
5 = mentally-physically incapable
6 = other

37. Code Values:

0 = 1975 data only

1 = 1976 data only

2 = Both 1975 and 1976 data

38. Code Values:

20 = No

1 = Yes (stickered vehicle)

0 = Missing

APPENDIX B

DETAILED DATA TABULATIONS - 1975

Table B-1

Vehicle Year

Year	Monroe County	Monroe Sample	Expected	$(O-E)^2/E$
pre-1960	1101	5	28.3	19.2
1960	201	1	5.4	3.5
1961	232	2	5.9	2.6
1962	543	8	13.9	2.5
1963	928	14	23.9	4.1
1964	1544	20	39.8	9.8
1965	2767	37	71.2	16.4
1966	3436	50	88.5	16.7
1967	4000	78	103.0	6.1
1968	5290	101	136.2	9.1
1969	6019	154	155.0	0.0
1970	5734	159	147.7	0.9
1971	6479	168	166.8	0.0
1972	8379	232	215.8	1.2
1973	9608	292	247.4	8.0
1974	8468	315	218.0	43.2
1975	4626	150	119.1	8.0
Total	69355	1786		151.1

Chi-squared goodness of fit

χ^2=151.1 significance level = 0.0

Table B-2

Vehicle Year

Year	Jackson County	Jackson Sample	Expected	$(O-E)^2/E$
pre-1960	731	13	85.1	61.1
1960	221	8	25.7	12.2
1961	270	10	31.4	14.5
1962	605	32	70.4	20.9
1963	995	37	115.8	53.6
1964	1668	117	194.2	30.7
1965	3188	215	371.2	65.7
1966	4089	320	476.1	51.2
1967	5074	457	590.8	30.3
1968	6356	671	740.1	22.5
1969	7407	815	862.5	2.6
1970	7172	772	835.1	4.7
1971	7967	930	927.7	0.0
1972	10108	1388	1176.9	37.8
1973	12084	1598	1407.1	25.9
1974	10021	1450	1166.8	68.7
1975	6491	1060	755.8	122.4
	84447	9833		625.7

Chi-squared goodness of fit

$\chi^2 = 625.7$ significance level = 0.0

Table B-3

Vehicle Year

Year	Michigan	Sample	Expected	$(O-E)^2/E$
pre-1960	23861	18	63.6	32.7
1960	7165	9	19.1	5.3
1961	10043	12	26.8	8.1
1962	24787	40	66.0	10.2
1963	45801	51	122.0	41.3
1964	78133	137	208.2	24.3
1965	151632	252	404.1	57.2
1966	196794	370	524.4	45.5
1967	240481	535	640.8	17.5
1968	324817	712	865.6	27.2
1969	372177	969	991.8	0.5
1970	376082	931	1002.2	5.0
1971	430967	1098	1148.5	2.2
1972	529313	1620	1410.5	31.1
1973	614186	1890	1636.7	39.2
1974	540359	1765	1439.9	73.4
1975	393236	1210	1047.9	25.1
Total	4360052	11619		445.8

Chi-squared goodness of fit

χ^2=445.8 significance level = 0.0

Table B-3

Vehicle Year

Year	Michigan	Sample	Expected	$(O-E)^2/E$
pre-1960	23861	18	63.6	32.7
1960	7165	9	19.1	5.3
1961	10043	12	26.8	8.1
1962	24787	40	66.0	10.2
1963	45801	51	122.0	41.3
1964	78133	137	208.2	24.3
1965	151632	252	404.1	57.2
1966	196794	370	524.4	45.5
1967	240481	535	640.8	17.5
1968	324817	712	865.6	27.2
1969	372177	969	991.8	0.5
1970	376082	931	1002.2	5.0
1971	430967	1098	1148.5	2.2
1972	529313	1620	1410.5	31.1
1973	614186	1890	1636.7	39.2
1974	540359	1765	1439.9	73.4
1975	393236	1210	1047.9	25.1
Total	4360052	11619		445.8

Chi-squared goodness of fit

χ^2=445.8 significance level = 0.0

Table B-5

Vehicle Mileage
(thousands of miles)

Mileage	Monroe Count	Monroe %	Jackson Count	Jackson %	Total Count	Total %
0-10	169	9.5	903	9.2	1072	9.2
10-20	225	12.6	998	10.1	1223	10.5
20-30	224	12.5	1152	11.7	1376	11.8
30-40	208	11.6	1188	12.0	1396	12.0
40-50	223	12.5	1188	12.0	1411	12.1
50-60	179	10.0	1047	10.6	1226	10.5
60-70	168	9.4	951	9.6	1119	9.6
70-80	139	7.8	796	8.1	935	8.0
80-90	111	6.2	632	6.4	743	6.4
90-100	56	3.1	426	4.3	482	4.1
100-110	38	2.1	262	2.7	300	2.6
110-120	19	1.1	163	1.7	182	1.6
120-130	9	0.5	83	0.8	92	0.8
130-140	7	0.4	34	0.3	41	0.4
140-150	6	0.3	19	0.2	25	0.2
150-160	3	0.2	8	0.1	11	0.1
>160	2	0.1	15	0.2	17	0.1
Total	1786		9865		11651	

Mean 45.82
Std. Deviation 29.83

Chi-square test of homogeneity*

χ^2=21.456 significance level = 0.044

*Due to small numbers vehicles with over 120,000 miles were collapsed into one category.

Table B-6

Vehicle Year

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
Pre 1960	5	0.3	13	0.2	18	0.2
1960	1	0.1	8	0.1	9	0.1
1961	2	0.1	10	0.1	12	0.1
1962	8	0.4	32	0.3	40	0.3
1963	14	0.8	37	0.4	51	0.4
1964	20	1.1	117	1.2	137	1.2
1965	37	2.1	215	2.2	252	2.2
1966	50	2.8	320	3.2	370	3.2
1967	78	4.4	457	4.6	535	4.6
1968	101	5.7	611	6.2	712	6.1
1969	154	8.6	815	8.3	969	8.3
1970	159	8.9	772	7.8	931	8.0
1971	168	9.4	930	9.4	1098	9.4
1972	232	13.0	1388	14.1	1620	13.9
1973	292	16.3	1598	16.2	1890	16.2
1974	315	17.6	1450	14.7	1765	15.1
1975	150	8.4	1060	10.7	1210	10.4
1976	0	0.0	27	0.3	27	0.2
TOTAL	1786		9865		11651	

Chi-square test for homogeneity*

χ^2=31.036 significance level = 0.0133

* category 1976 deleted due to inspections in Monroe county before model year 1976.

Table B-7

Vehicle Make*

	Monroe Count	Monroe %	Jackson Count	Jackson %	Total Count	Total %
Passenger Cars						
Buick	81	4.7	791	8.3	872	7.8
Cadillac	27	1.6	108	1.1	135	1.2
Chevrolet	379	22.0	2242	23.6	2621	23.4
Chrysler	29	1.7	141	1.5	170	1.5
Dodge	85	4.9	420	4.4	505	4.5
Ford	338	19.6	1448	15.3	1786	15.9
Imperial	3	0.2	2	0.0	5	0.0
Jeep	9	0.5	11	0.1	20	0.2
Lincoln	13	0.8	27	0.3	40	0.4
Mercury	116	6.7	334	3.5	450	4.0
Oldsmobile	123	7.1	891	9.4	1014	9.0
Plymouth	111	6.4	488	5.1	599	5.3
Pontiac	91	5.3	877	9.2	968	8.6
Volkswagen	40	2.3	138	1.5	178	1.6
Other	30	1.7	263	2.7	293	2.6
Trucks						
Chevrolet	95	5.5	540	5.7	635	5.7
Dodge	24	1.4	131	1.4	155	1.4
Ford	114	6.6	487	5.1	601	5.4
GMC	10	0.6	95	1.0	105	0.9
International	2	0.1	17	0.2	19	0.2
Willys	6	0.3	33	0.3	39	0.3
Total	1726		9484		11210	

Chi-square test for homogeneity**

$\chi^2 = 149.79$ significance level = 0.00

* Due to some unexplained error, no American Motors vehicles were recognized in this table.

** Due to small expected values, Imperial and Jeep were included with other passenger cars and Willys and International were combined for trucks.

Table B-8

Total Vehicle

	Monroe		Jackson		Total	
	%	Count	%	Count	%	Count
Pass	48.1	859	50.5	4981	50.1	5840
Fail	51.9	927	49.5	4884	49.9	5811
Total		1786		9865		11651

Chi-square test of homogeneity

Table B-9

Tabulations of Variables Recorded by Service Troopers

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
NUMBER OF TRIPS						
Number						
1	1604	89.8	9416	95.4	11020	94.6
2	178	10.0	432	4.4	610	5.2
3	3	0.2	15	0.2	18	0.2
4	1	0.1	0	0.0	1	0.0
5	0	0.0	2	0.0	2	0.0
Total	1786		9865		11651	
SAFETY GLASS						
Category						
Pass	1786	100.0	9865	100.0	11651	100.0
Fail	0	0.0	0	0.0	0	0.0
Total	1786	100.0	9865	100.0	11651	100.0
VISION IMPAIRED						
Pass	1750	98.0	9485	96.1	11235	96.5
Fail	36	2.0	380	3.9	416	3.6
Total	1786		9865		11651	
GLASS DEFECTS						
Pass	1750	98.0	9485	96.1	11235	96.4
Fail	36	2.0	380	3.9	416	3.6
Total	1786		9865		11651	
WIPERS						
Pass	1725	96.6	9509	96.4	11234	96.4
Fail	61	3.4	356	3.6	417	3.6
Total	1786		9865		11651	
WASHERS						
Pass	1437	80.5	8355	84.7	9792	84.0
Fail	349	19.5	1510	15.3	1856	16.0
Total	1786		9865		11651	
WIPERS OR WASHERS						
Pass	1403	78.6	8138	82.5	9541	81.9
Fail	383	21.4	1727	17.5	2110	18.1
Total	1786		9865		11651	

Table B-9 Continued

	Monroe Count	Monroe %	Jackson Count	Jackson %	Total Count	Total %
MIRROR						
Pass	1745	97.7	9625	97.6	11370	97.6
Fail	41	2.3	240	2.4	281	2.4
Total	1786		9865		11651	
TOTAL VISION DEFECTS						
Number						
0	1361	76.2	7782	78.9	9143	78.5
1	367	20.5	1726	17.5	2093	18.0
2	54	3.0	314	3.2	368	3.2
3	4	0.2	40	0.4	44	0.3
4	0	0.0	3	0.0	3	0.0
Total	1786		9865		11651	
FRONT DIRECTIONAL LIGHTS						
Pass	1689	94.6	9382	95.1	11071	95.0
Fail	97	5.4	483	4.9	580	5.0
Total	1786		9865		11651	
HIGH BEAM						
Pass	1672	93.6	9128	92.5	10800	92.7
Fail	114	6.4	737	7.5	851	7.3
Total	1786		9865		11651	
LOW BEAM						
Pass	1750	98.0	9619	97.5	11369	97.6
Fail	36	2.0	246	2.5	282	2.4
Total	1786		9865		11651	
HEADLIGHT AIM						
Pass	1747	97.8	9593	97.2	11340	97.3
Fail	39	2.2	272	2.8	311	2.7
Total	1786		9865		11651	
HEADLIGHT OUTPUT						
Pass	1771	99.2	9733	98.7	11504	98.7
Fail	15	0.8	132	1.3	147	1.3
Total	1786		9865		11651	

Table B-9 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
TOTAL HEADLIGHT						
Pass	1656	92.7	8961	90.8	10617	93.8
Fail	130	7.3	904	9.2	1034	8.9
Total	1786		9865		11651	
TAIL LIGHTS						
Pass	1687	94.5	9237	93.6	10924	93.8
Fail	99	5.5	628	6.4	727	6.2
Total	1786		9865		11651	
STOP LIGHTS						
Pass	1672	93.6	9135	92.6	10807	92.8
Fail	114	6.4	730	7.4	844	7.2
Total	1786		9865		11651	
REAR DIRECTIONAL						
Pass	1658	92.8	9186	93.1	10844	93.1
Fail	128	7.2	679	6.9	807	6.9
Total	1786		9865		11651	
PLATE LIGHT						
Pass	1479	82.8	8211	83.2	9690	83.2
Fail	307	17.2	1654	16.8	1961	16.8
Total	1786		9865		11651	
BEAM INDICATOR						
Pass	1786	100.0	9861	100.0	11651	100.0
Fail	0	0.0	4	0.0	0	0.0
Total	1876		9865		11651	
TOTAL LIGHTS						
Pass	1230	68.9	6655	67.5	7885	67.7
Fail	556	31.1	3210	32.5	3766	32.3
Total	1786		9865		11651	
MAJOR LIGHT DEFECTS						
0	1461	81.8	7839	79.5	9300	79.8
1	162	9.1	1095	11.1	1257	10.8
2	84	4.7	444	4.5	528	4.5
3	52	2.9	344	3.5	396	3.4
4	20	1.1	107	1.1	127	1.1
>4	7	0.4	36	0.3	43	0.4
Total	1786		9865		11651	

Table B-9 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
TOTAL LIGHT DEFECTS						
Number						
0	1230	68.9	6655	67.5	7885	67.7
1	336	18.8	1929	19.6	2265	19.4
2	116	6.5	625	6.3	741	6.4
3	57	3.2	386	3.9	443	3.8
4	35	2.0	165	1.7	200	1.7
5	7	0.4	71	0.7	78	0.7
>5	4	0.2	32	0.3	36	0.3
Total	1785		9863		11648	
Missing	1		2		3	
HORN						
Pass	1725	96.6	9573	97.0	11298	97.0
Fail	61	3.4	292	3.0	353	3.0
Total	1786		9865		11651	
STEERING						
Pass	1785	99.9	9828	99.6	11613	99.7
Fail	1	0.1	37	0.4	38	0.3
Total	1786		9865		11651	
FOOT BRAKE						
Pass	1769	99.0	9768	99.0	11537	99.0
Fail	17	1.0	97	1.0	114	1.0
Total	1786		9865		11651	
PARKING BRAKE						
Pass	1568	87.8	8910	90.3	10473	89.9
Fail	218	12.2	955	9.7	1173	10.1
Total	1786		9865		11651	
FOOT AND PARKING BRAKE						
Pass	1560	87.3	8857	89.8	10417	89.4
Fail	226	12.7	1008	10.2	1234	10.6
Total	1786		9865		11651	
TIRE BULGES OR BREAK						
Pass	1784	99.9	9837	99.7	11621	99.7
Fail	2	0.1	28	0.3	30	0.3
Total	1786		9865		11651	

Table B-9 Continued

	Monroe Count	Monroe %	Jackson Count	Jackson %	Total Count	Total %
TIRE TREAD						
Pass	1567	87.7	8691	88.1	10258	88.0
Fail	219	12.3	1174	11.9	1393	12.0
Total	1786		9865		11651	
TIRES, OVERALL						
Pass	1566	87.7	8684	88.0	10250	88.0
Fail	220	12.3	1181	12.0	1401	12.0
Total	1786		9865		11651	
CONTROL DEFECTS						
number						
0	1553	87.0	8612	87.3	10165	87.2
1	227	12.7	1174	11.9	1401	12.0
2	6	0.3	75	0.8	81	0.7
3	0	0.0	4	0.0	4	0.1
Total	1786		9865		11651	
EXHAUST NOISE						
Pass	1621	90.8	9010	91.3	10631	91.2
Fail	165	9.2	855	8.7	1020	8.8
Total	1786		9865		11651	
EXHAUST SMOKE						
Pass	1759	98.5	9751	98.8	11510	98.8
Fail	27	1.5	114	1.2	141	1.2
Total	1786		9865		11651	
TOTAL EXHAUST						
Pass	1605	89.9	8947	90.7	10552	90.6
Fail	181	10.1	918	9.3	1099	9.4
Total	1786		9865		11651	
OPERATOR's LICENSE						
Pass	1765	98.8	9709	98.4	11474	98.5
No license	14	0.8	107	1.1	121	1.0
Suspended or Revoked	0	0.0	6	0.1	6	0.1
Other	7	0.4	40	0.4	47	0.4
More than 1 no pass	0	0.0	3	0.0	3	0.0
Total	1786		9865		11651	

Table B-9 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
VEHICLE REGISTRATION						
Pass	1783	99.8	9857	99.9	11640	99.8
Improper	0	0.0	5	0.1	5	0.1
None on person	3	0.2	3	0.0	6	0.1
Total	1786		9865		11651	
VEHICLE INSURANCE						
Pass	1785	99.9	9861	100.0	11646	100.0
No Compliance	0	0.0	3	0.0	3	0.0
None on Person	1	0.1	1	0.0	2	0.0
Total	1786		9865		11651	
TOTAL OPERATOR						
Pass	1762	98.7	9700	98.3	11462	98.4
Fail	24	1.3	165	1.7	189	1.6
Total	1786		9865		11651	
MAJOR MECHANICAL						
number						
0	1035	58.0	5836	59.2	6811	58.5
1	361	20.2	1961	19.9	2322	19.9
2	196	11.0	973	9.9	1169	10.0
3	91	5.3	477	4.8	538	4.9
4	51	2.9	303	3.1	354	3.0
5	24	1.3	150	1.5	174	1.5
6	18	1.0	80	0.8	90	0.8
7	3	0.2	51	0.5	54	0.5
8	3	0.2	19	0.2	22	0.2
9	1	0.1	13	0.1	14	0.1
10	0	0.0	2	0.0	2	0.0
Total	1786		9865		11651	
TOTAL MECHANICAL						
number						
0	904	50.6	5206	52.8	6110	52.4
1	389	21.8	2000	20.3	2389	20.5
2	226	12.7	1211	12.3	1437	12.3
3	127	7.1	619	6.3	746	6.4
4	67	3.8	356	3.6	423	3.6
5	32	1.8	207	2.1	239	2.1
6	23	1.3	113	1.1	136	1.2
7	11	0.6	71	0.7	82	0.7
8	3	0.2	34	0.3	37	0.3
9	2	0.1	29	0.3	31	0.3
10	1	0.1	10	0.1	11	0.1
11	1	0.1	6	0.1	7	0.1
12	0	0.0	3	0.0	3	0.0
Total	1786		9865		11651	

Table B-9 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
TOTAL VEHICLE						
Pass	859	48.1	4981	50.5	5840	50.1
Fail	927	51.9	4884	49.5	5811	49.9
Total	1786		9865		11651	
SUMMONS ISSUED						
number						
0	1731	96.9	9397	95.3	11128	95.5
1	21	1.2	134	1.4	155	1.3
2	1	0.1	3	0.0	4	0.0
Miscode	33	1.8	31	3.4	364	3.2
Total	1786		9865		11651	
SEAT BELTS						
Yes	199	11.2	1129	11.4	1328	11.4
No	1585	88.8	8732	88.6	10317	88.6
Total	1784		9861		11645	

Notes on TAble B-9

EXPLANATION OF CHECKLANE VARIABLES

Number of Trips - This is the number of times drivers said they had been inspected by a checklane, including the current inspection.

Safety Glass - This was a check to see whether windows and windshields were made of safety glass.

Vision Impaired - A vehicle failed if the glass was cracked or if the windshield had too many stickers on it, thus impairing vision.

Total Vision Defects - The number of vision items failed (safety glass, vision impaired, wipers, washers, and mirror).

Headlight Output - A vehicle failed if the headlights were not sufficiently bright.

Major Light Defects - The number of major light items that failed (front directional, high beams, low beams, tail lights, stop lights, and rear directional).

Total Light Defects - The number of major light defects plus the number of other light items that failed (headlight aim, and plate light).

Foot Brake - A vehicle failed this item if it was clear that the driver pressed the brake pedal to the floor.

Parking Brake - The driver was asked to set the parking brake and then slowly accelerate. If the parking brake did not seem to hold, the vehicle failed this item.

Control Defects - The number of control-related items that failed (steering, foot brake, tire bulges or brake, and tire tread).

Major Mechanical - The number of vision defects, major light defects and control defects, plus the number of exhaust defects (exhaust noise and exhaust smoke).

Notes on Table B-9 Continued

Total Mechanical - The number of vision defects, total light defects, and control defects, plus the number of exhaust defects and horn.

Summons Issued - The number of summonses issued by the enforcement officer.

Seat Belts - The service officers observed whether the passengers in the vehicle wore seat belts.

Table B-10

Tire Pressures

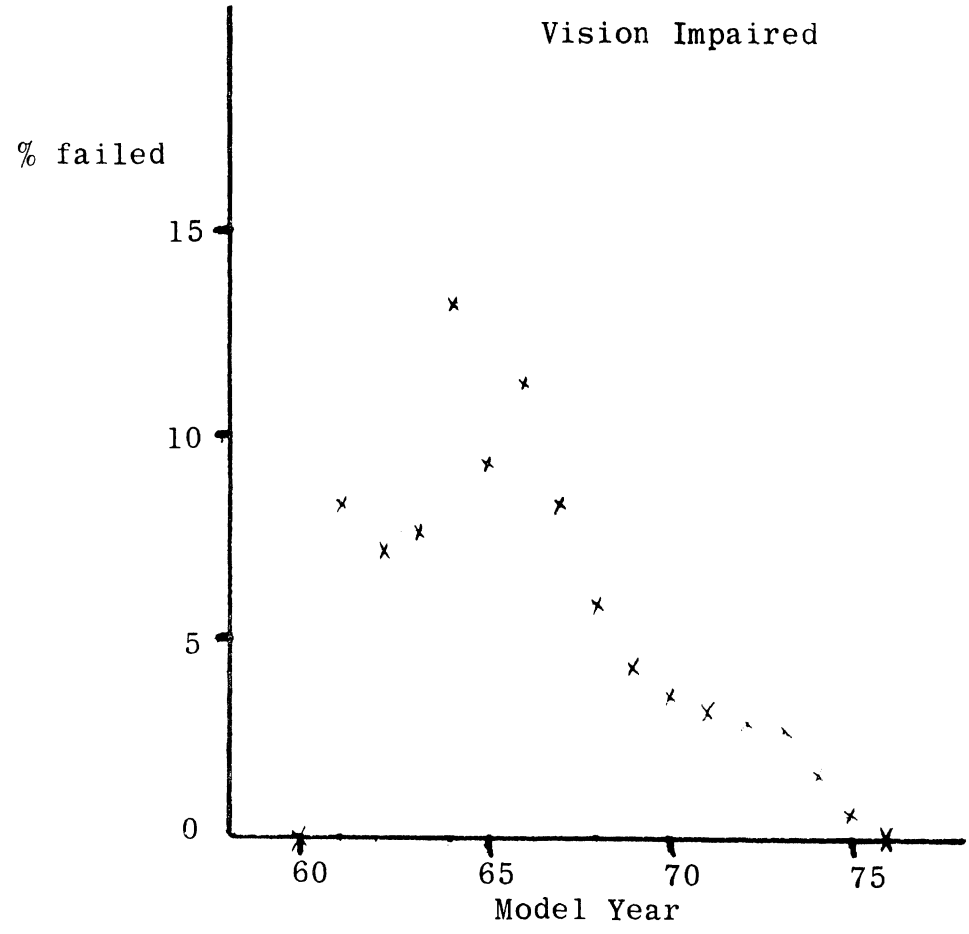
	Monroe Count	Monroe %	Jackson Count	Jackson %	Total Count	Total %
LEFT-FRONT TIRE PRESSURE (PSI)						
<10	0	0.0	0	0.0	0	0.0
10-15	2	0.7	6	0.3	8	0.3
15-20	2	0.7	95	4.7	97	4.2
20-25	23	7.7	360	18.0	383	16.6
25-30	82	27.4	858	42.8	940	40.8
30-35	143	47.8	537	26.8	680	29.5
35-40	33	11.0	92	4.6	125	5.4
40-45	9	3.0	38	1.9	47	2.0
45-50	3	1.0	10	0.5	13	0.6
50-55	1	0.3	8	0.4	9	0.4
>55	1	0.3	1	0.0	2	0.1
Total	299		2005		2304	
Missing	0		13		13	
LEFT-REAR TIRE PRESSURE (PSI)						
<10	0	0.0	0	0.0	0	0.0
10-15	2	0.7	28	1.4	30	1.3
15-20	4	1.3	108	5.4	112	4.9
20-25	36	12.0	376	18.8	412	17.9
25-30	85	28.4	851	42.5	936	40.6
30-35	132	44.1	503	25.1	635	27.6
35-40	27	9.0	87	4.3	114	5.0
40-45	7	2.3	25	1.2	32	1.4
45-50	2	0.7	17	0.8	19	0.8
50-55	2	0.7	8	0.4	10	0.4
>55	2	0.7	1	0.0	3	0.1
Total	299		2004		2303	
Missing	0		14		14	
RIGHT-FRONT TIRE PRESSURE (PSI)						
<10	0	0.0	0	0.0	0	0.0
10-15	0	0.0	15	0.7	15	0.7
15-20	11	3.7	96	4.8	107	4.7
20-25	31	10.5	351	17.5	382	16.6
25-30	97	32.8	876	43.8	973	42.4
30-35	121	40.9	524	26.2	645	28.1
35-40	21	7.1	90	4.5	111	4.8
40-45	8	2.7	33	1.6	41	1.8
45-50	5	1.7	10	0.5	15	0.7
50-55	0	0.0	6	0.3	6	0.3
>55	2	0.7	0	0.0	2	0.1
Total	296		2001		2297	
Missing	3		17		20	

Table B-10 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
RIGHT-REAR TIRE PRESSURE (PSI)						
<10	0	0.0	3	0.1	3	0.1
10-15	1	0.3	29	1.4	30	1.3
15-20	4	1.3	131	6.5	135	5.9
20-25	36	12.0	384	19.2	420	18.3
25-30	96	32.1	841	42.0	937	40.7
30-35	122	40.8	466	23.3	588	25.6
35-40	29	9.7	101	35.0	130	5.6
40-45	5	1.7	31	1.5	36	1.6
45-50	2	0.7	13	0.6	15	0.7
50-55	3	1.0	2	0.1	5	0.2
>55	1	0.3	1	0.0	2	0.2
Total	299		2002		2301	
Missing	0		16		16	
FRONT LOADED RECOMMENDED TIRE PRESSURE (PSI)						
15-20	0	0.0	2	1.0	2	1.0
20-25	0	0.0	78	40.6	78	40.6
25-30	0	0.0	87	45.3	87	45.3
30-35	0	0.0	24	12.5	24	12.5
35-40	0	0.0	1	0.5	1	0.5
Total	0		192		192	
Missing	0		1826		1826	
REAR LOADED RECOMMENDED TIRE PRESSURE (PSI)						
20-25	0	0.0	19	9.9	19	9.9
25-30	0	0.0	101	52.6	101	52.6
30-35	0	0.0	67	34.9	67	34.9
35-40	0	0.0	5	2.6	5	2.6
Total	0		192		192	
Missing	0		1826		1826	
FRONT UNLOADED RECOMMENDED TIRE PRESSURE (PSI)						
15-20	0	0.0	3	0.9	3	0.9
20-25	0	0.0	183	57.7	183	57.7
25-30	0	0.0	123	38.8	123	38.8
30-35	0	0.0	8	2.5	8	2.5
Total	0		317		317	
Missing	0		1701		1701	

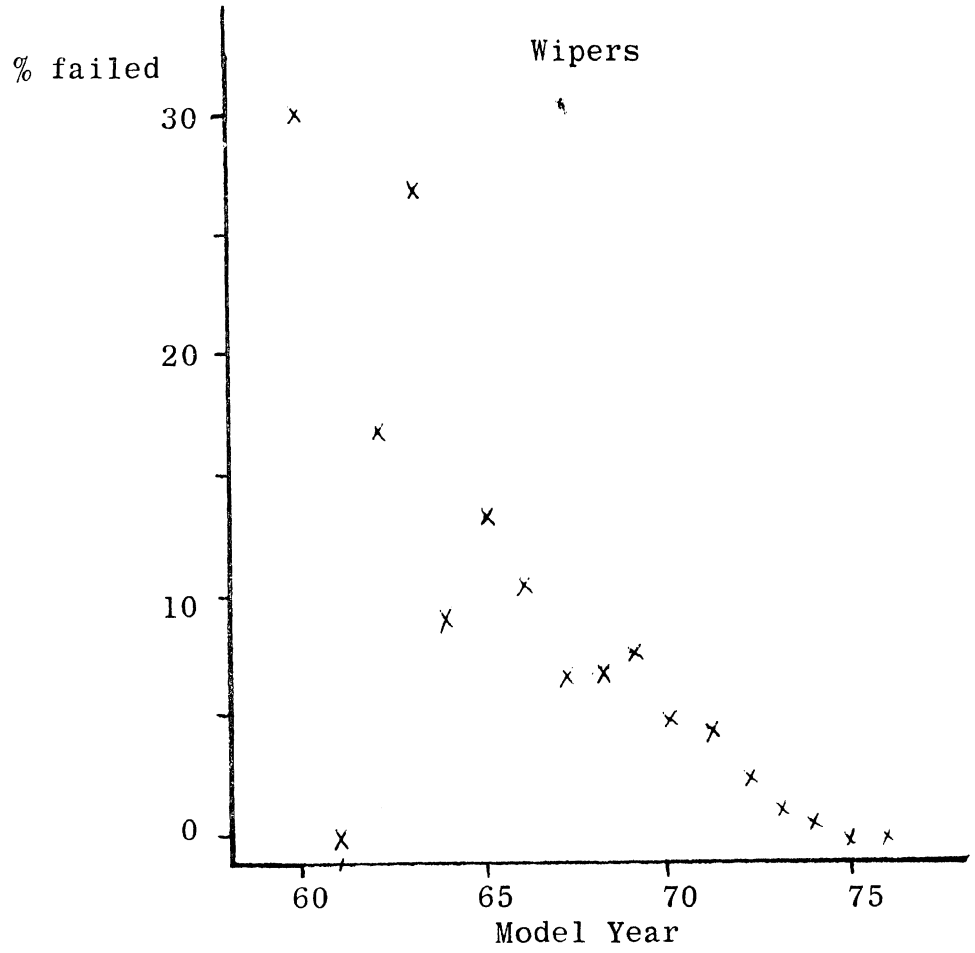
Table B-10 Continued

	Monroe Count	Monroe %	Jackson Count	Jackson %	Total Count	Total %
REAR UNLOADED RECOMMENDED TIRE PRESSURE (PSI)						
20-25	0	0.0	116	36.6	116	36.6
25-30	0	0.0	155	48.9	155	48.9
30-35	0	0.0	40	14.5	40	14.5
Total	0		311		311	
Missing	0		1701		1701	



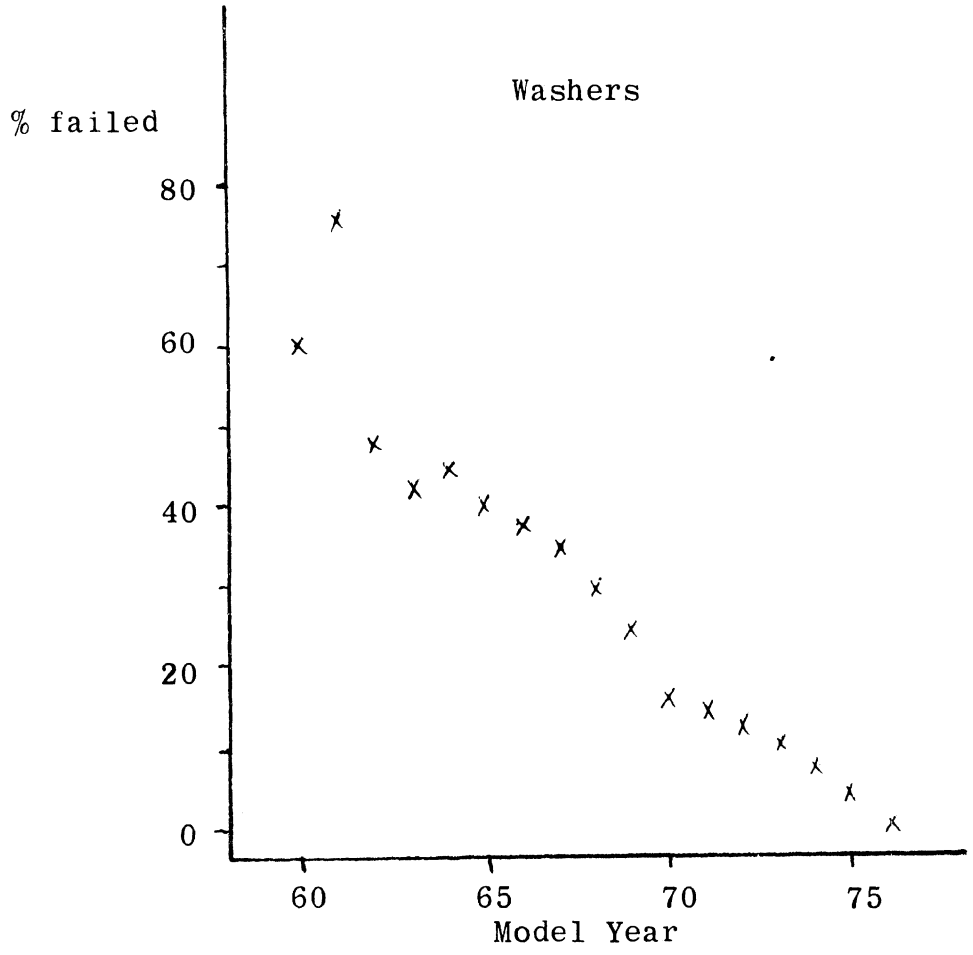
Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	1	8.3
1962	42	3	7.1
1963	53	4	7.5
1964	144	19	13.2
1965	270	25	9.3
1966	385	44	11.4
1967	552	45	8.2
1968	748	44	5.9
1969	1023	43	4.2
1970	981	33	3.4
1971	1169	36	3.1
1972	1712	49	2.9
1973	1998	54	2.7
1974	1890	31	1.6
1975	1299	8	0.6
1976	27	0	0.0
Total	12315	439	3.6

Figure B-1



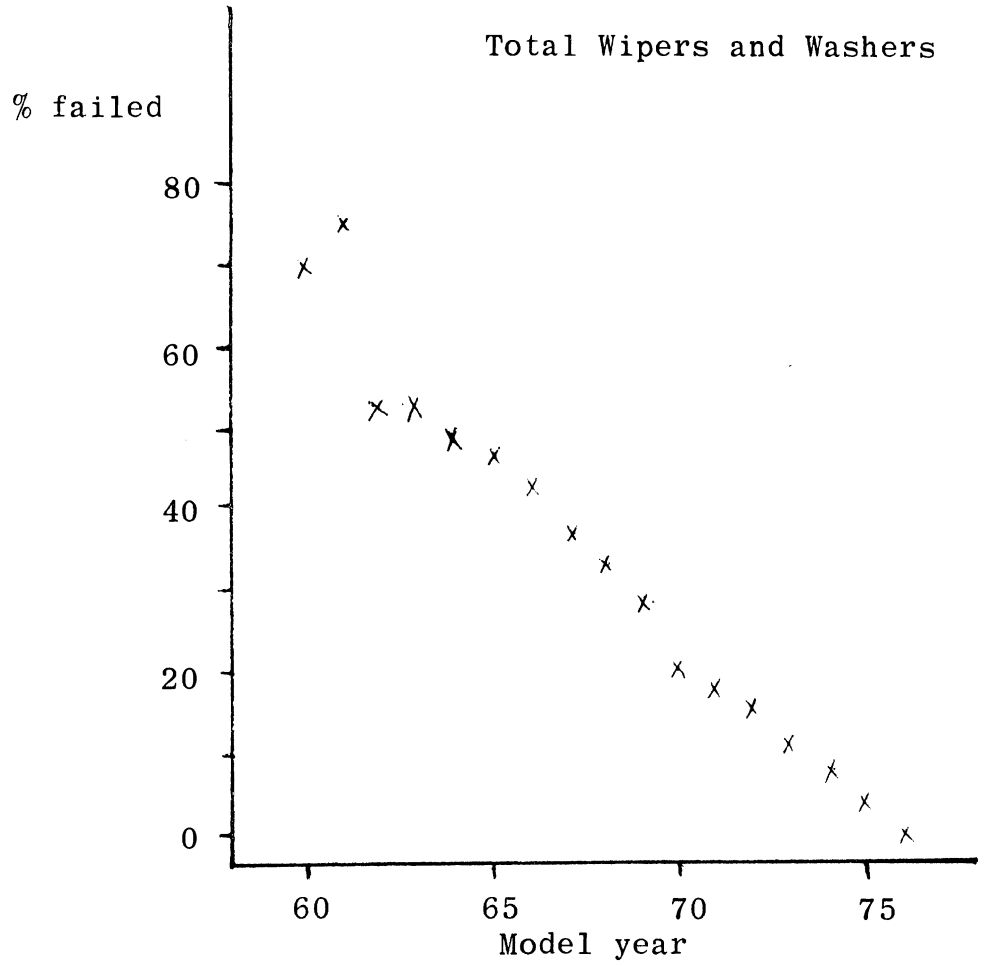
Year	Total	Failed	% Failing
1960	10	3	3.0
1961	12	0	0.0
1962	42	7	16.7
1963	53	14	26.4
1964	144	13	9.0
1965	270	35	13.0
1966	385	40	10.4
1967	552	35	6.3
1968	748	48	6.4
1969	1023	75	7.3
1970	981	47	4.8
1971	1169	52	4.4
1972	1712	39	2.3
1973	1998	19	1.0
1974	1890	10	0.5
1975	1299	0	0.0
1976	27	0	0.0
Total	12315	437	3.5

Figure B-2



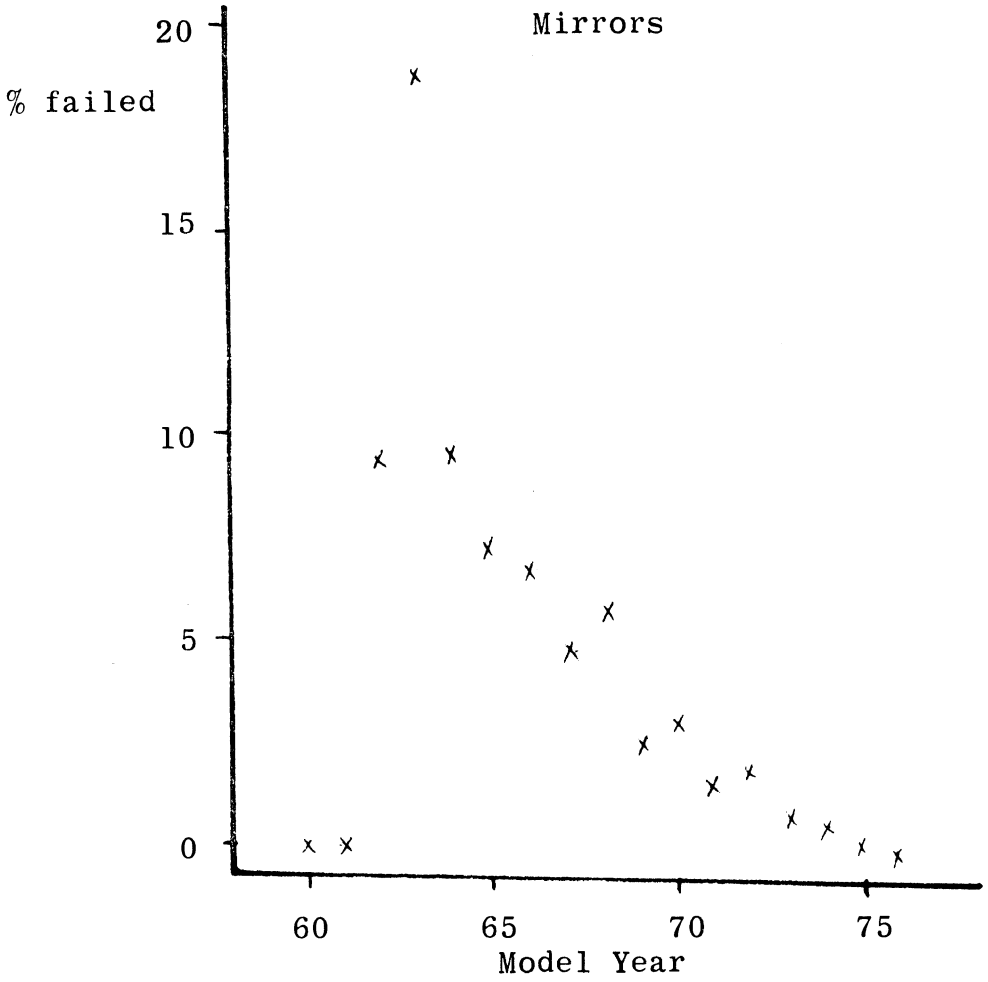
Year	Total	Failed	% Failing
1960	10	6	60.0
1961	12	9	75.0
1962	42	20	47.6
1963	53	22	41.5
1964	144	64	44.4
1965	270	106	39.3
1966	385	143	37.1
1967	552	191	34.6
1968	748	222	29.7
1969	1023	247	24.1
1970	981	156	15.9
1971	1169	167	14.3
1972	1712	231	13.5
1973	1998	206	10.3
1974	1890	148	7.8
1975	1299	52	4.0
1976	27	0	0.0
Total	12315	1990	16.2

Figure B-3



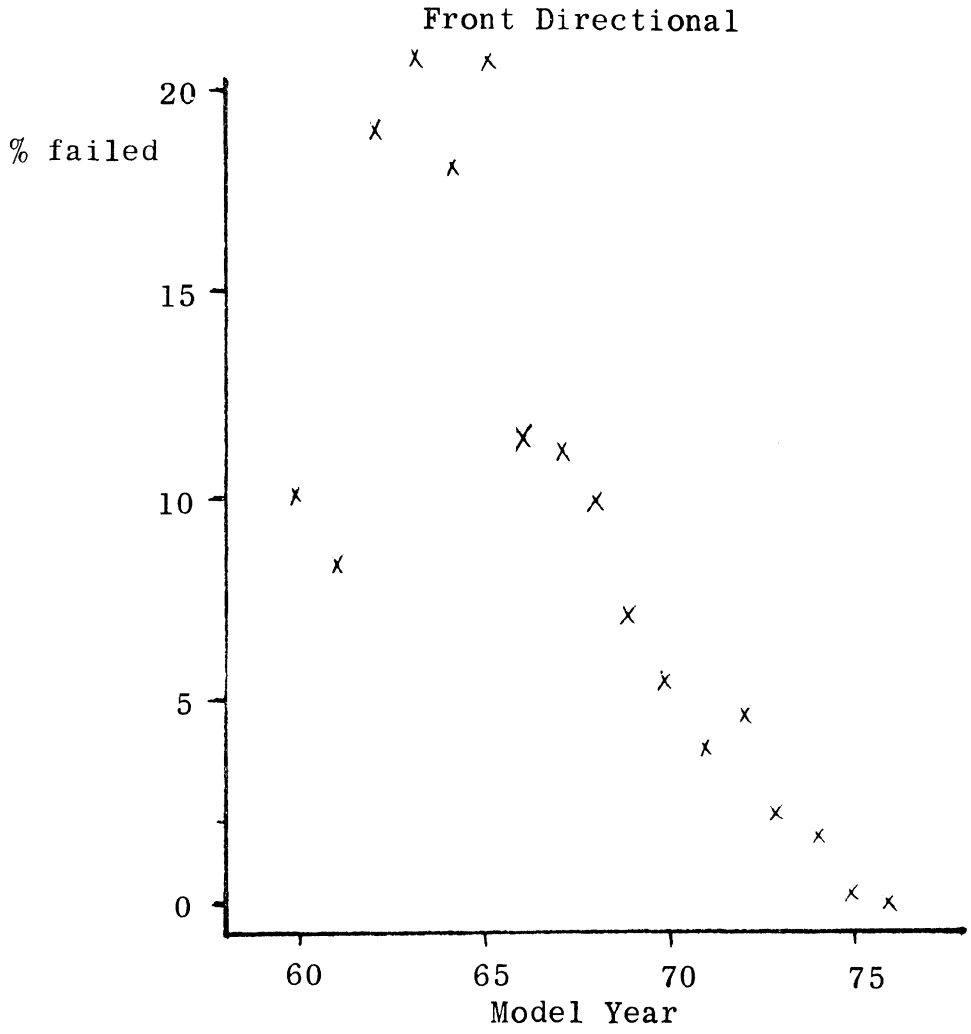
Year	Total	Failed	% Failing
1960	10	7	70.0
1961	12	9	75.0
1962	42	22	52.4
1963	53	28	52.8
1964	144	70	48.6
1965	270	126	46.7
1966	385	163	42.3
1967	552	206	37.3
1968	748	245	32.8
1969	1023	287	28.1
1970	981	193	19.7
1971	1169	205	17.5
1972	1712	262	15.3
1973	1998	220	11.0
1974	1890	154	8.1
1975	1299	52	4.0
1976	27	0	0.0
Total	12315	2249	18.3

Figure B-4



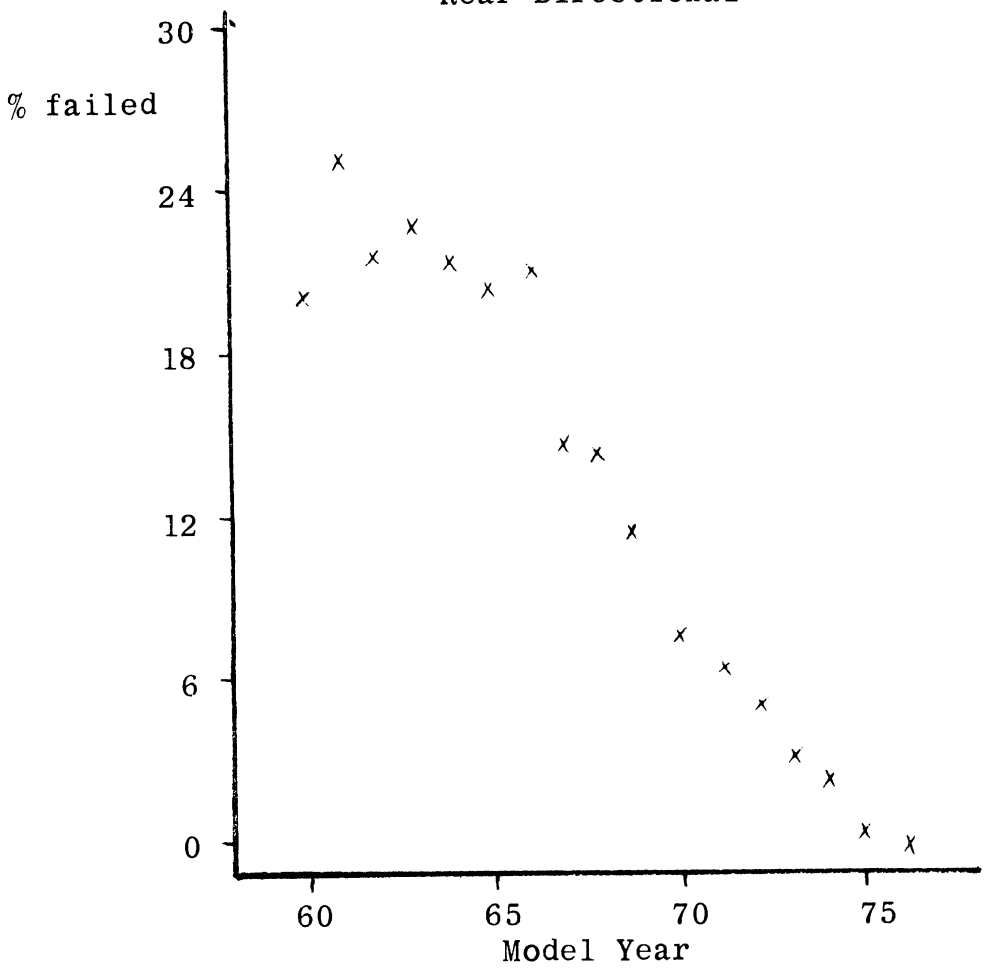
Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	0	0.0
1962	42	4	9.5
1963	53	10	18.9
1964	144	14	9.7
1965	270	20	7.4
1966	385	26	6.8
1967	552	27	4.9
1968	748	44	5.9
1969	1023	28	2.7
1970	981	30	7.9
1971	1169	20	1.7
1972	1712	35	2.0
1973	1998	20	1.0
1974	1890	14	0.7
1975	1299	4	0.3
1976	27	0	0.0
Total	12315	296	2.4

Figure B-5



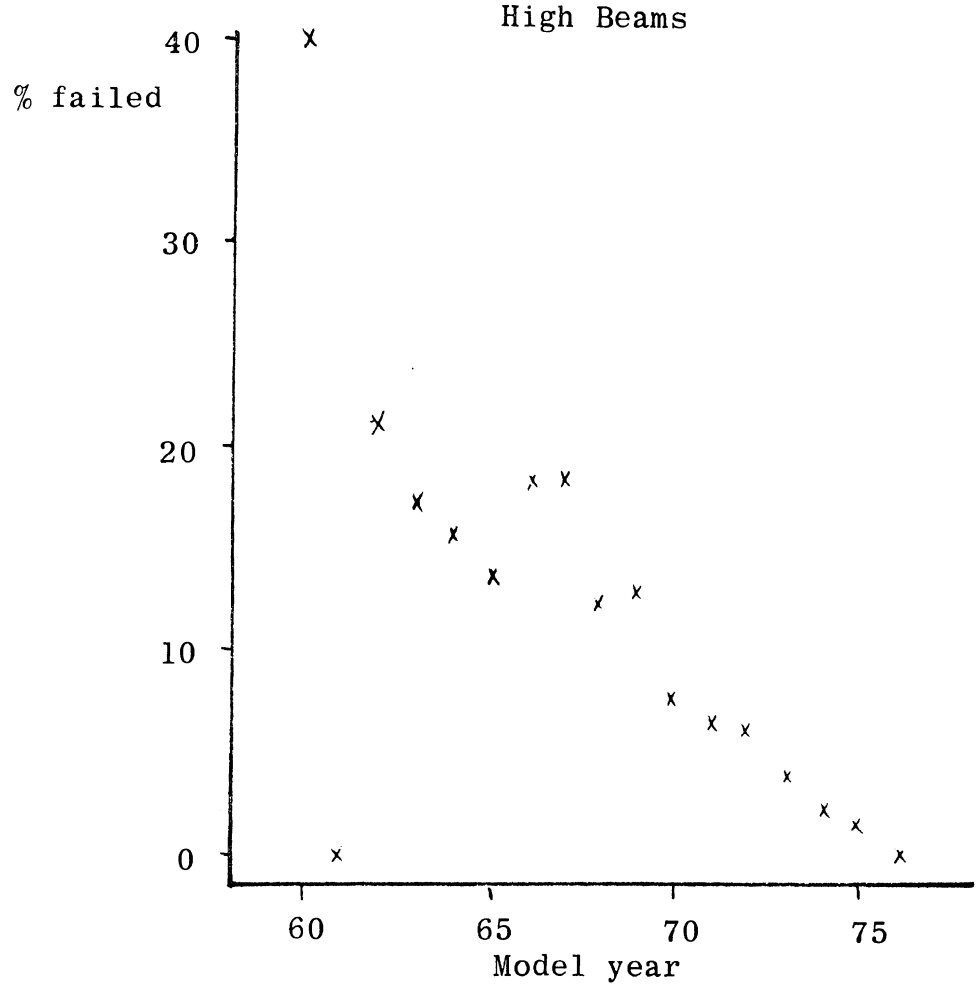
Year	Total	Failed	% Failing
1960	10	1	10.0
1961	12	1	8.3
1962	42	8	19.0
1963	53	11	20.8
1964	144	26	18.1
1965	270	56	20.7
1966	385	44	11.4
1967	552	62	11.2
1968	748	74	9.9
1969	1023	72	7.0
1970	981	54	5.5
1971	1169	45	3.8
1972	1712	78	4.6
1973	1998	43	2.2
1974	1890	31	1.6
1975	1299	2	0.2
1976	27	0	0.0
Total	12315	608	4.9

Figure B-6



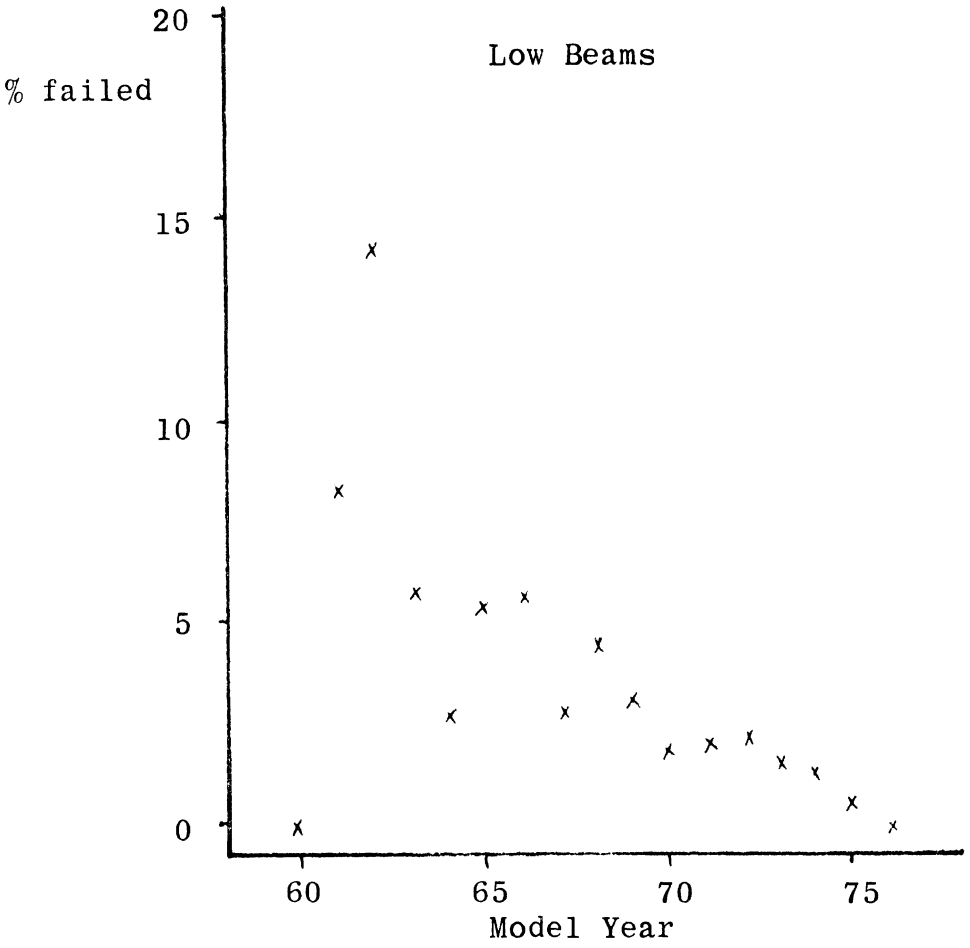
Year	Total	Failed	% Failing
1960	10	2	20.0
1961	12	3	25.0
1962	42	9	21.4
1963	53	12	22.6
1964	144	31	21.5
1965	270	54	20.0
1966	385	81	21.0
1967	552	81	14.7
1968	748	106	14.2
1969	1023	115	11.2
1970	981	75	7.6
1971	1169	73	6.2
1972	1712	87	5.1
1973	1998	62	3.1
1974	1890	47	2.5
1975	1299	6	0.5
1976	27	0	0.0
Total	12315	844	7.2

Figure B-7



Year	Total	Failed	% Failing
1960	10	4	40.0
1961	12	0	0.0
1962	42	9	21.4
1963	53	9	17.0
1964	144	23	16.0
1965	270	37	13.7
1966	385	70	18.2
1967	552	101	18.3
1968	748	93	12.4
1969	1023	132	12.9
1970	981	77	7.8
1971	1169	76	6.5
1972	1712	106	6.2
1973	1998	81	4.1
1974	1890	46	2.4
1975	1299	20	1.5
1976	27	0	0.0
Total	12315	884	7.2

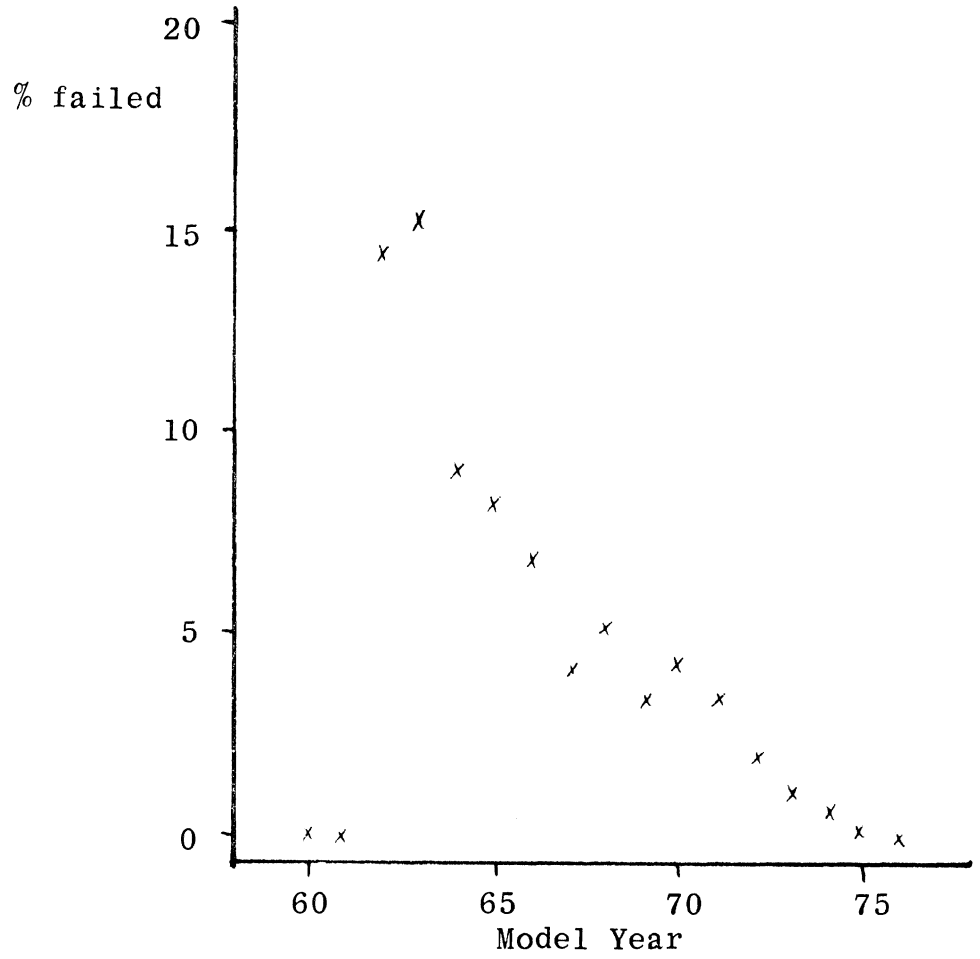
Figure B-8



Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	1	8.3
1962	42	6	14.3
1963	53	3	5.7
1964	144	4	2.8
1965	270	15	5.6
1966	385	22	5.7
1967	552	16	2.9
1968	748	34	4.5
1969	1023	33	3.2
1970	981	28	2.9
1971	1169	24	2.1
1972	1712	37	2.2
1973	1998	34	1.7
1974	1890	28	1.5
1975	1299	8	0.6
1976	27	0	0.0
Total	12315	293	2.4

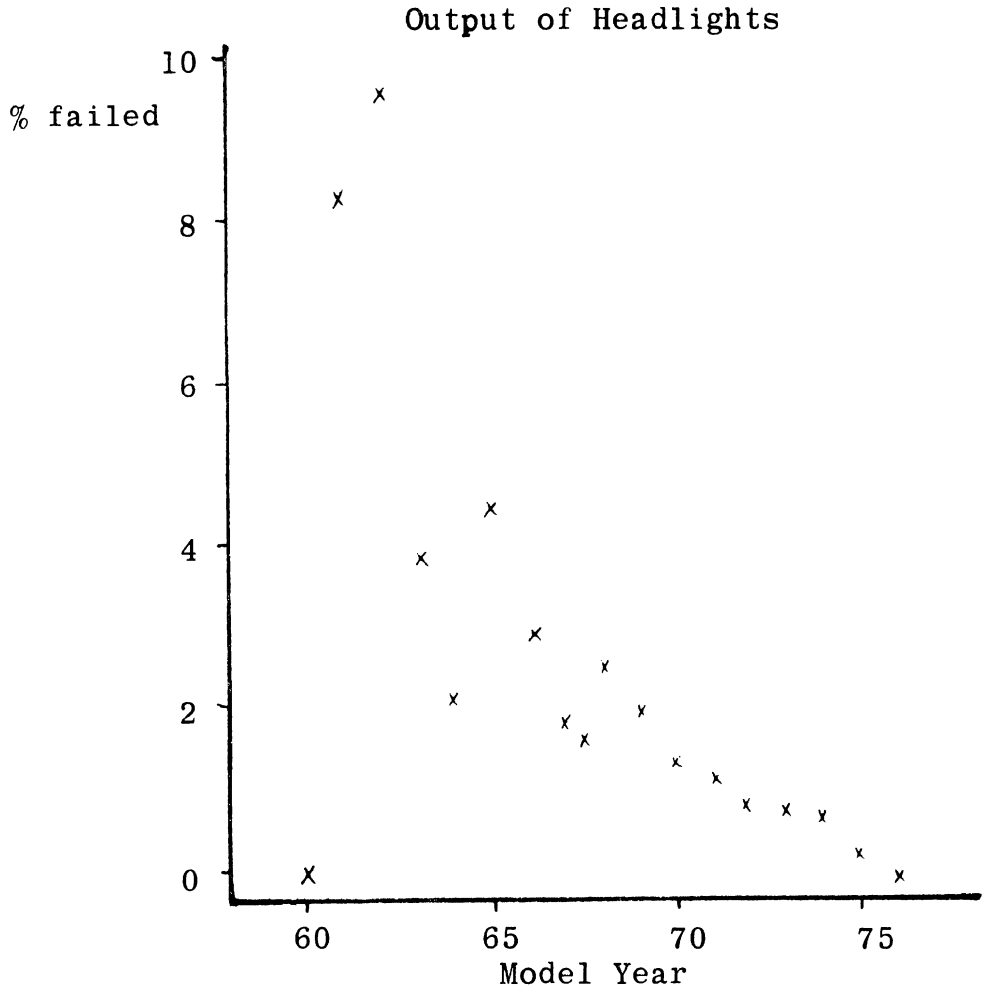
Figure B-9

Aim of Headlight



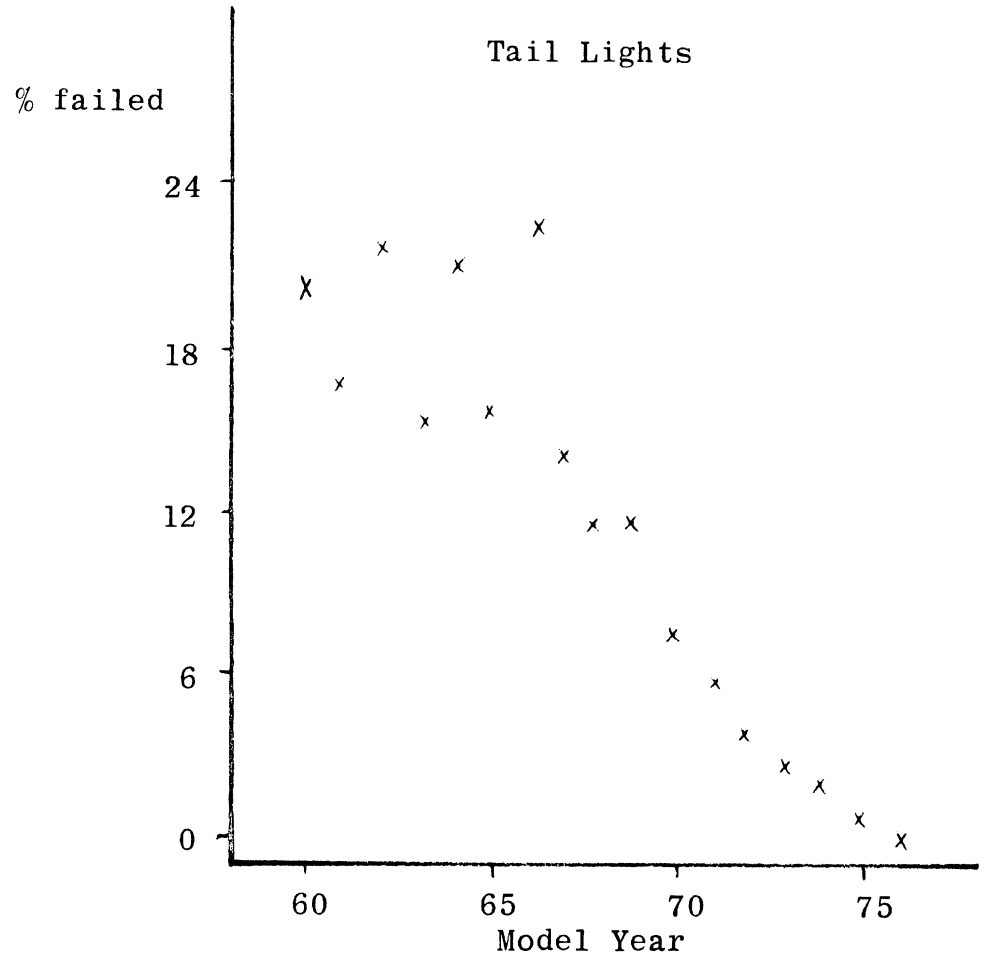
Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	0	0.0
1962	42	6	14.3
1963	53	8	15.1
1964	144	13	9.0
1965	270	22	8.1
1966	385	26	6.8
1967	552	23	4.2
1968	748	39	5.2
1969	1023	35	3.4
1970	981	41	4.2
1971	1169	39	3.3
1972	1712	34	2.0
1973	1998	22	1.1
1974	1890	12	0.6
1975	1299	2	0.2
1976	27	0	0.0
Total	12315	322	2.6

Figure B-10



Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	1	8.3
1962	42	4	9.5
1963	53	2	3.8
1964	144	3	2.1
1965	270	12	4.4
1966	385	11	2.9
1967	552	9	1.6
1968	748	19	2.5
1969	1023	19	1.9
1970	981	13	1.3
1971	1169	13	1.1
1972	1712	14	0.8
1973	1998	16	0.8
1974	1890	13	0.7
1975	1299	2	0.2
1976	27	0	0.0
Total	12315	151	1.2

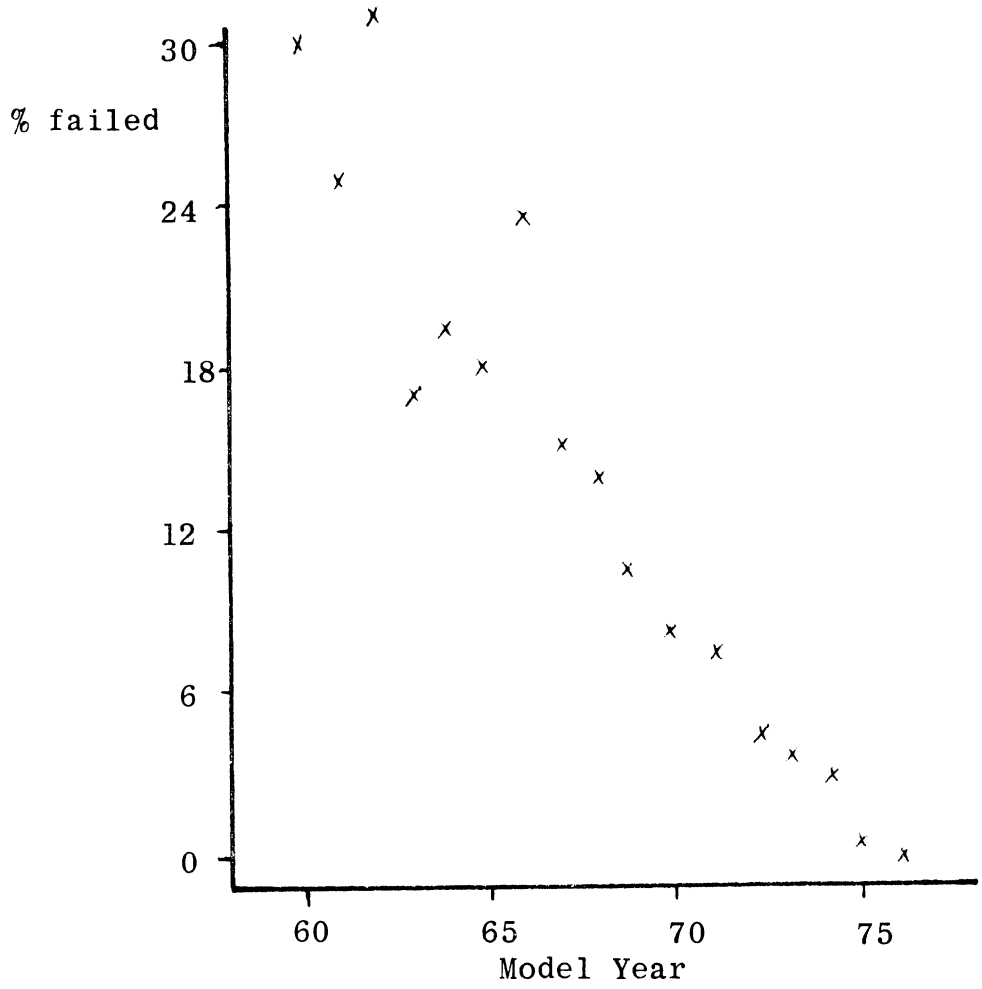
Figure B-11



Year	Total	Failed	% Failing
1960	10	2	20.0
1961	12	2	16.7
1962	42	9	21.4
1963	53	8	15.1
1964	144	30	20.8
1965	270	42	15.6
1966	385	87	22.6
1967	552	77	13.9
1968	748	83	11.1
1969	1023	115	11.2
1970	981	74	7.5
1971	1169	65	5.6
1972	1712	67	3.9
1973	1998	52	2.6
1974	1890	37	2.0
1975	1299	12	0.9
1976	27	0	0.0
Total	12315	762	6.2

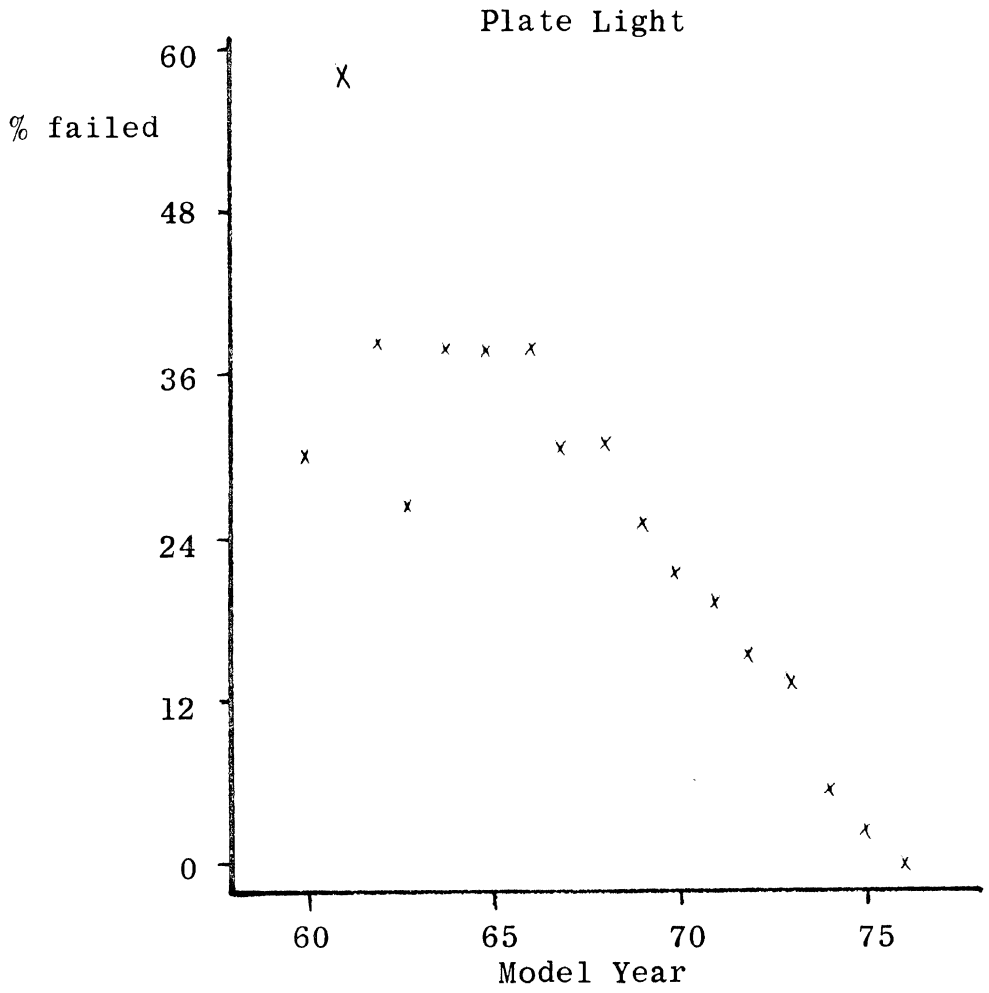
Figure B-12

Stop Lights



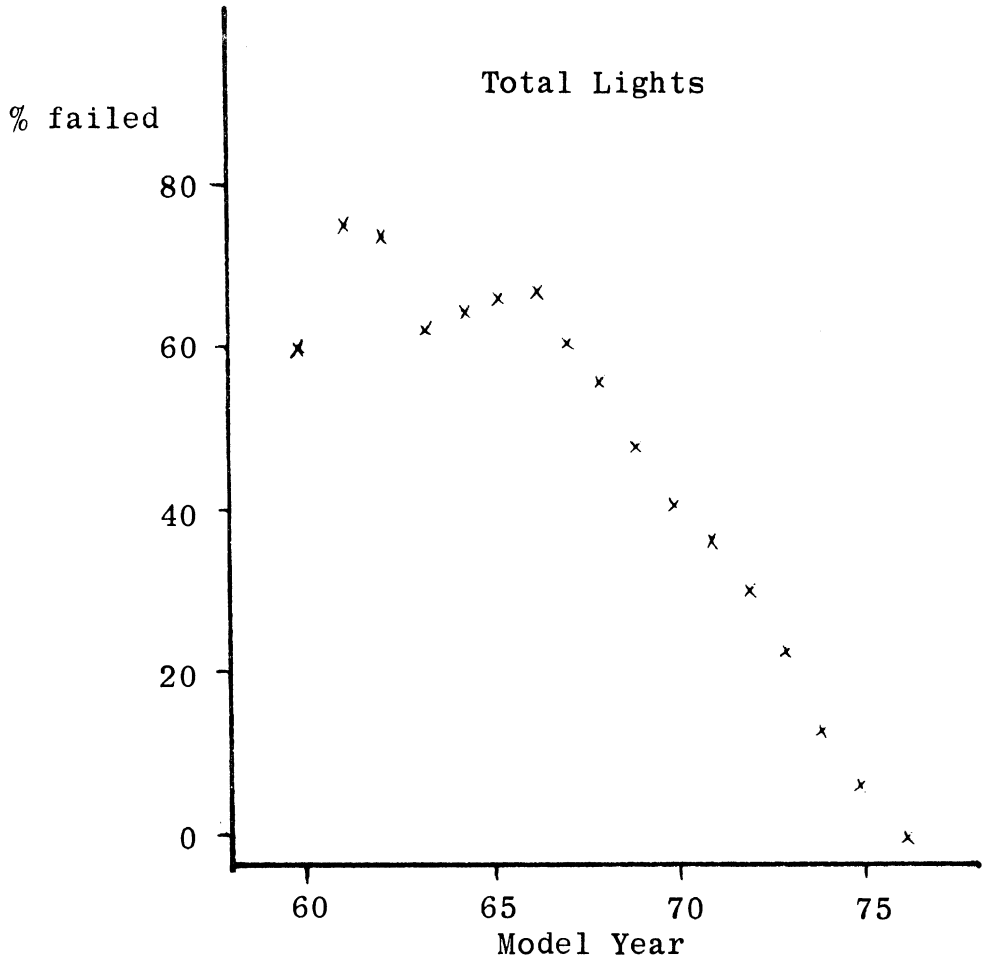
Year	Total	Failed	% Failing
1960	10	3	30.0
1961	12	3	25.0
1962	42	13	31.0
1963	53	9	17.0
1964	144	28	19.4
1965	270	49	18.1
1966	385	91	23.6
1967	552	84	15.2
1968	748	105	14.0
1969	1023	109	10.7
1970	981	80	8.2
1971	1169	86	7.4
1972	1712	80	4.7
1973	1998	73	3.7
1974	1890	57	3.0
1975	1299	7	0.5
1976	27	0	0.0
Total	12315	877	7.2

Figure B-13



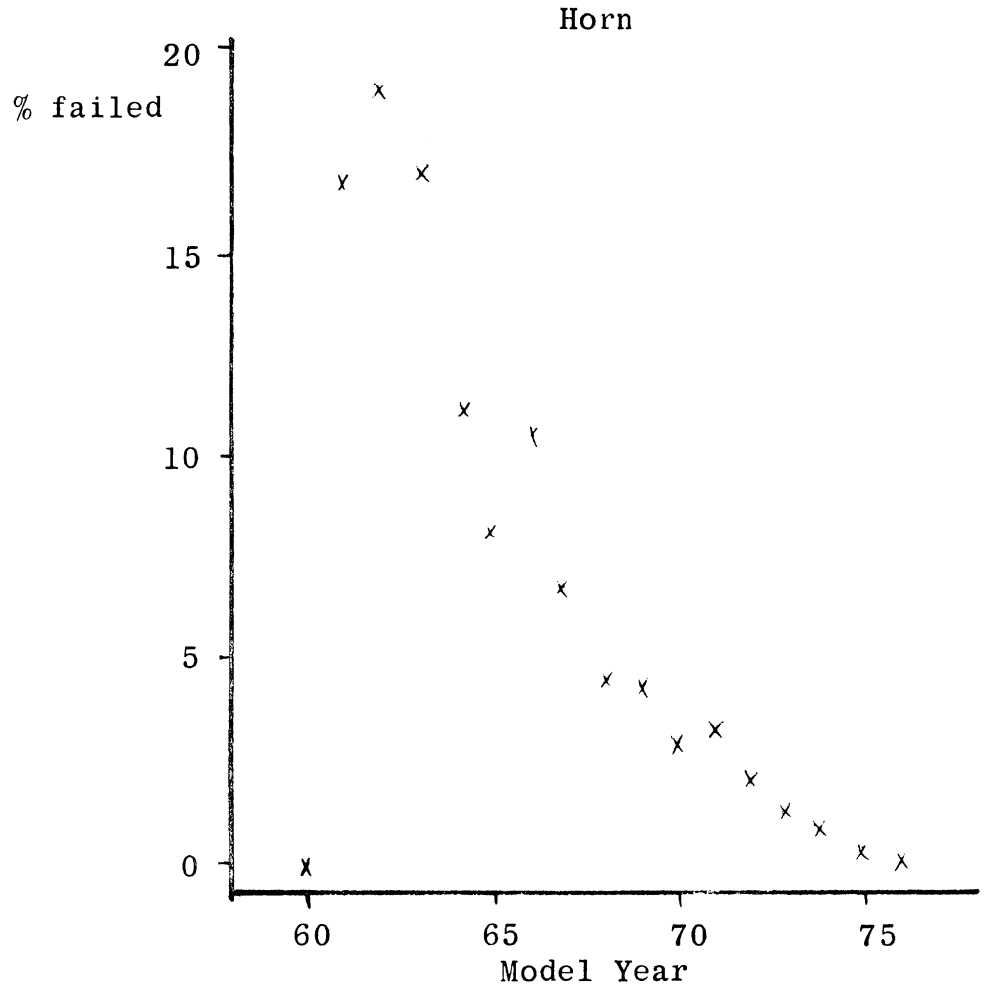
Year	Total	Failed	% Failing
1960	10	3	30.0
1961	12	7	58.3
1962	42	16	38.1
1963	53	14	26.4
1964	144	54	37.5
1965	270	101	37.4
1966	385	145	37.7
1967	552	167	30.3
1968	748	230	30.7
1969	1023	252	24.6
1970	981	210	21.4
1971	1169	223	19.1
1972	1712	264	15.4
1973	1998	262	13.1
1974	1890	97	5.1
1975	1299	35	2.7
1976	27	0	0.0
Total	12315	2080	16.9

Figure B-14



Year	Total	Failed	% Failing
1960	10	6	60.0
1961	12	9	75.0
1962	42	31	73.8
1963	53	33	62.3
1964	144	93	64.6
1965	270	176	65.2
1966	385	256	66.5
1967	552	337	61.1
1968	748	418	55.9
1969	1023	490	47.9
1970	981	398	40.6
1971	1169	429	36.7
1972	1712	513	30.0
1973	1998	454	22.7
1974	1890	248	13.1
1975	1299	74	5.7
1976	27	0	0.0
Total	12315	3965	32.2

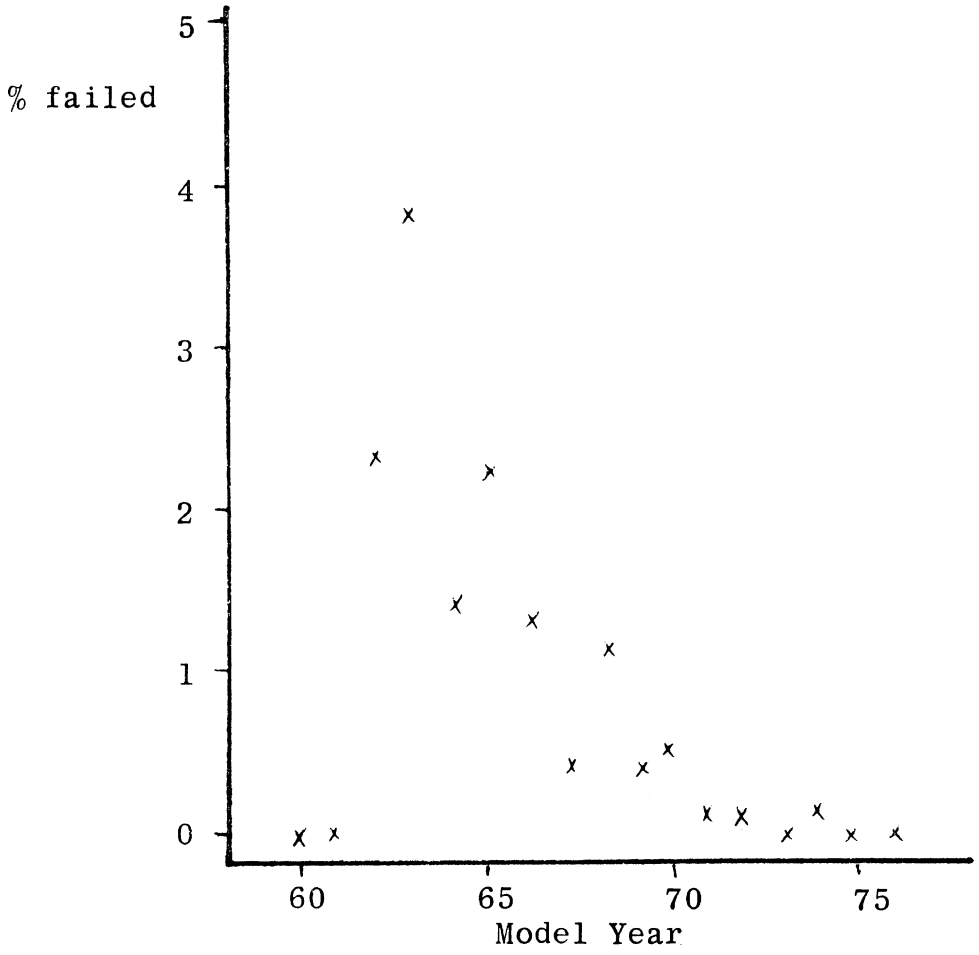
Figure B-15



Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	2	16.7
1962	42	8	19.0
1963	53	9	17.0
1964	144	16	11.1
1965	270	22	8.1
1966	385	41	10.6
1967	552	38	6.9
1968	748	34	4.5
1969	1023	45	4.4
1970	981	29	3.0
1971	1169	39	3.3
1972	1712	36	2.1
1973	1998	26	1.3
1974	1890	19	1.0
1975	1299	2	0.2
1976	27	0	0.0
Total	12315	366	3.0

Figure B-16

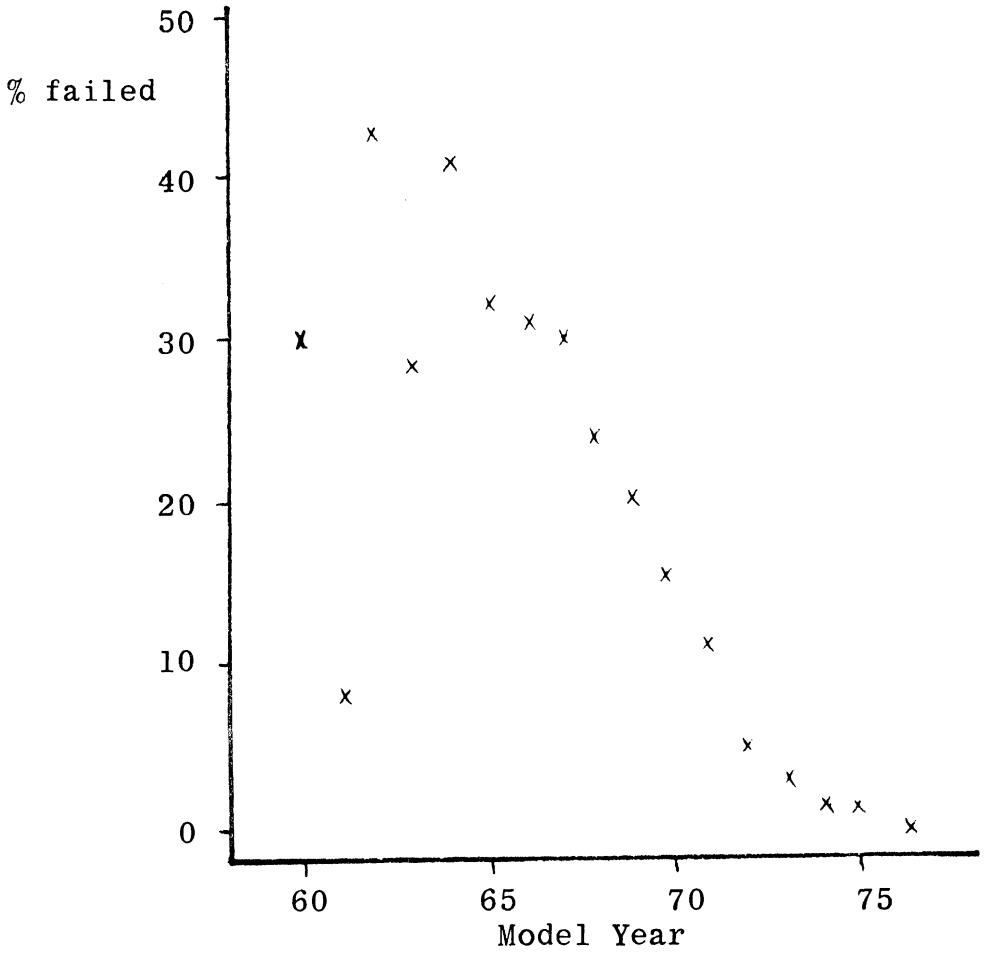
Steering



Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	0	0.0
1962	42	1	2.4
1963	53	2	3.8
1964	144	2	1.4
1965	270	6	2.2
1966	385	5	1.3
1967	552	2	0.4
1968	748	8	1.1
1969	1023	4	0.4
1970	981	5	0.5
1971	1169	1	0.1
1972	1712	1	0.1
1973	1998	0	0.0
1974	1890	1	0.1
1975	1299	0	0.0
1976	27	0	0.0
Total	12315	38	0.3

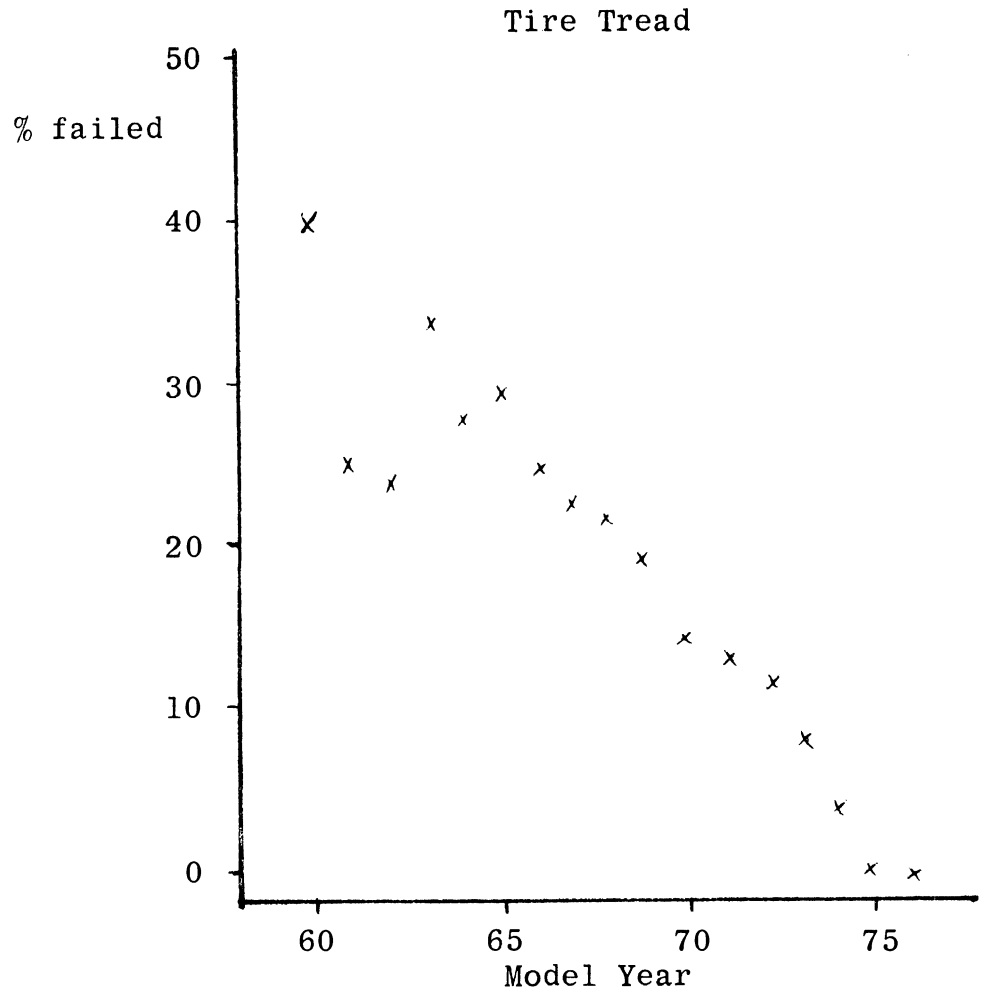
Figure B-17

Parking Brake



Year	Total	Failed	% Failing
1960	10	3	30.0
1961	12	1	8.3
1962	42	18	42.9
1963	53	15	28.3
1964	144	55	38.2
1965	270	84	31.1
1966	385	114	29.6
1967	552	160	29.0
1968	748	171	22.9
1969	1023	193	18.9
1970	981	147	15.0
1971	1169	125	10.7
1972	1712	90	5.3
1973	1998	65	3.3
1974	1890	24	1.3
1975	1299	13	1.0
1976	27	0	0.0
Total	12315	1278	10.4

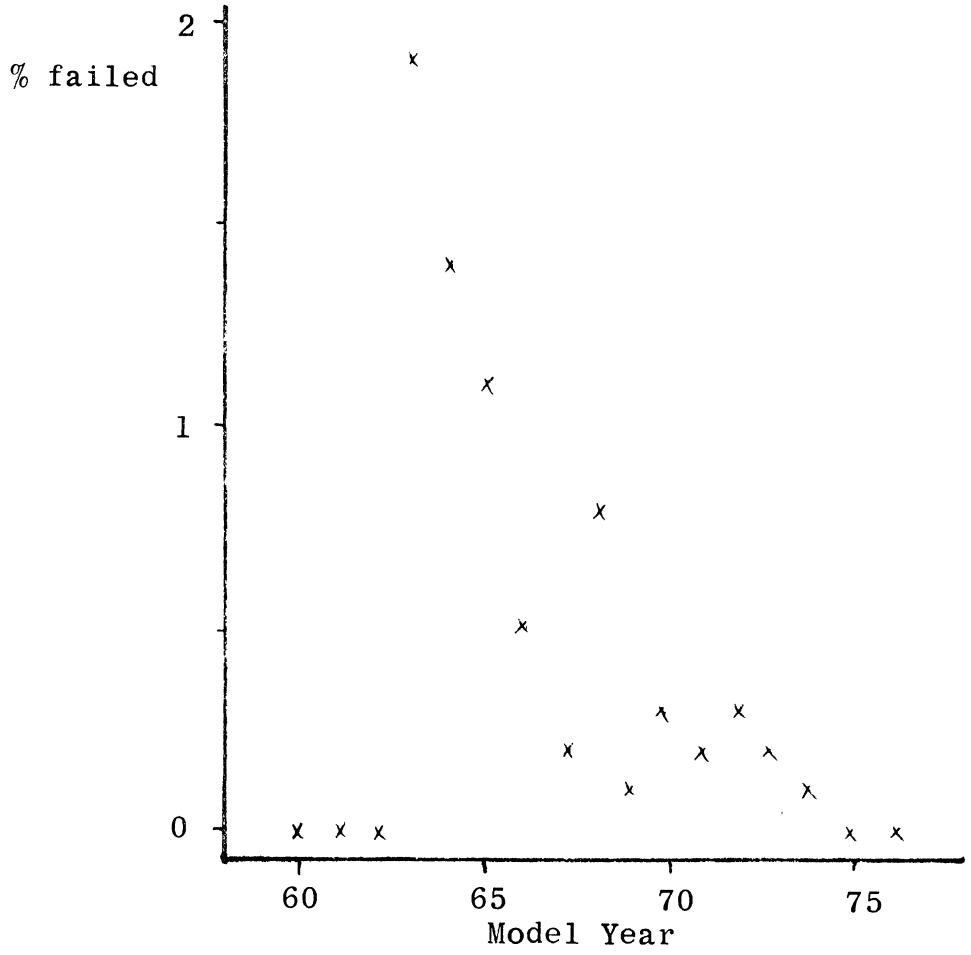
Figure B-18



Year	Total	Failed	% Failing
1960	10	4	40.0
1961	12	3	25.0
1962	42	10	23.8
1963	53	18	34.0
1964	144	40	27.8
1965	270	79	29.3
1966	385	96	24.9
1967	552	126	22.8
1968	748	177	23.7
1969	1023	195	19.1
1970	981	140	14.3
1971	1169	156	13.3
1972	1712	197	11.5
1973	1998	173	8.7
1974	1890	81	4.3
1975	1299	4	0.3
1976	27	0	0.0
Total	12315	1499	

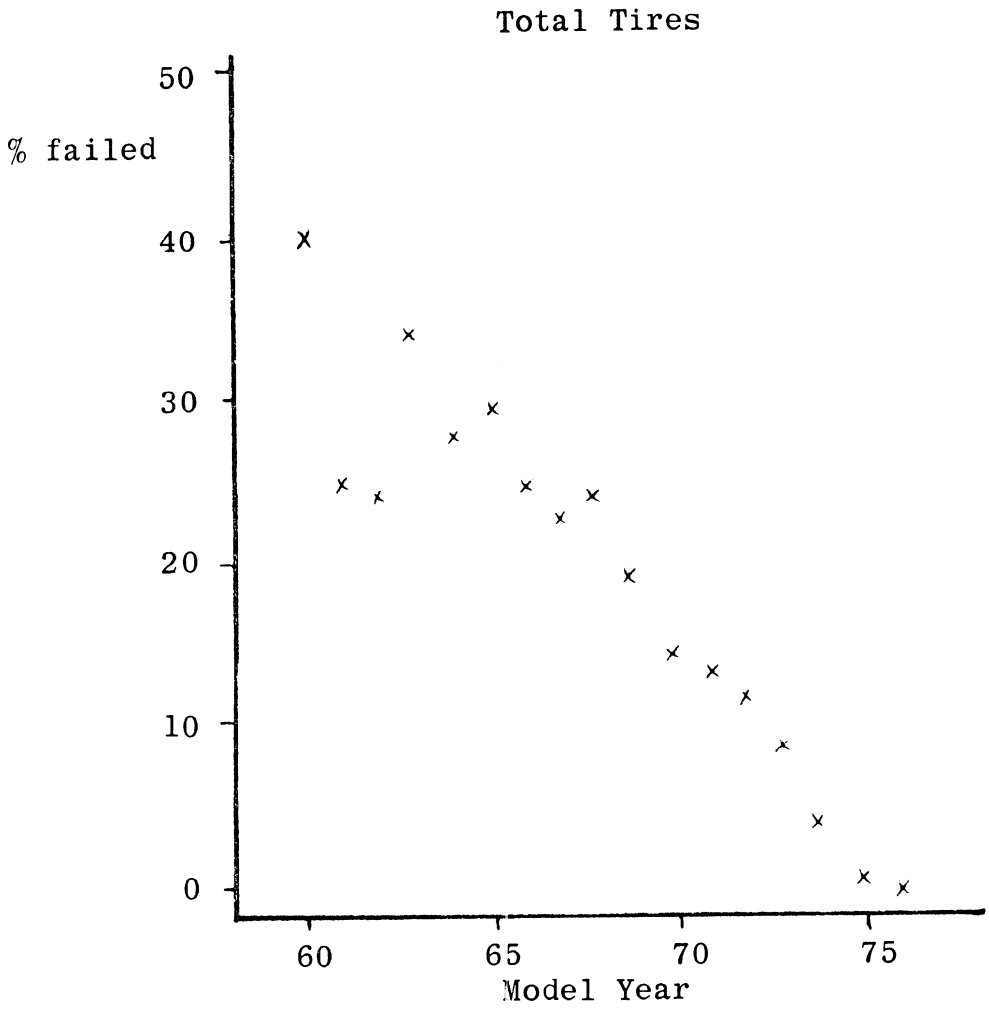
Figure B-19

Tire Bulges or Break



Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	0	0.0
1962	42	0	0.0
1963	53	1	1.9
1964	144	2	1.4
1965	270	3	1.1
1966	385	2	0.5
1967	552	1	0.2
1968	748	6	0.8
1969	1023	1	0.1
1970	981	3	0.3
1971	1169	2	0.2
1972	1712	5	0.3
1973	1998	4	0.2
1974	1890	1	0.1
1975	1299	0	0.0
1976	27	0	0.0
Total	12315	31	0.3

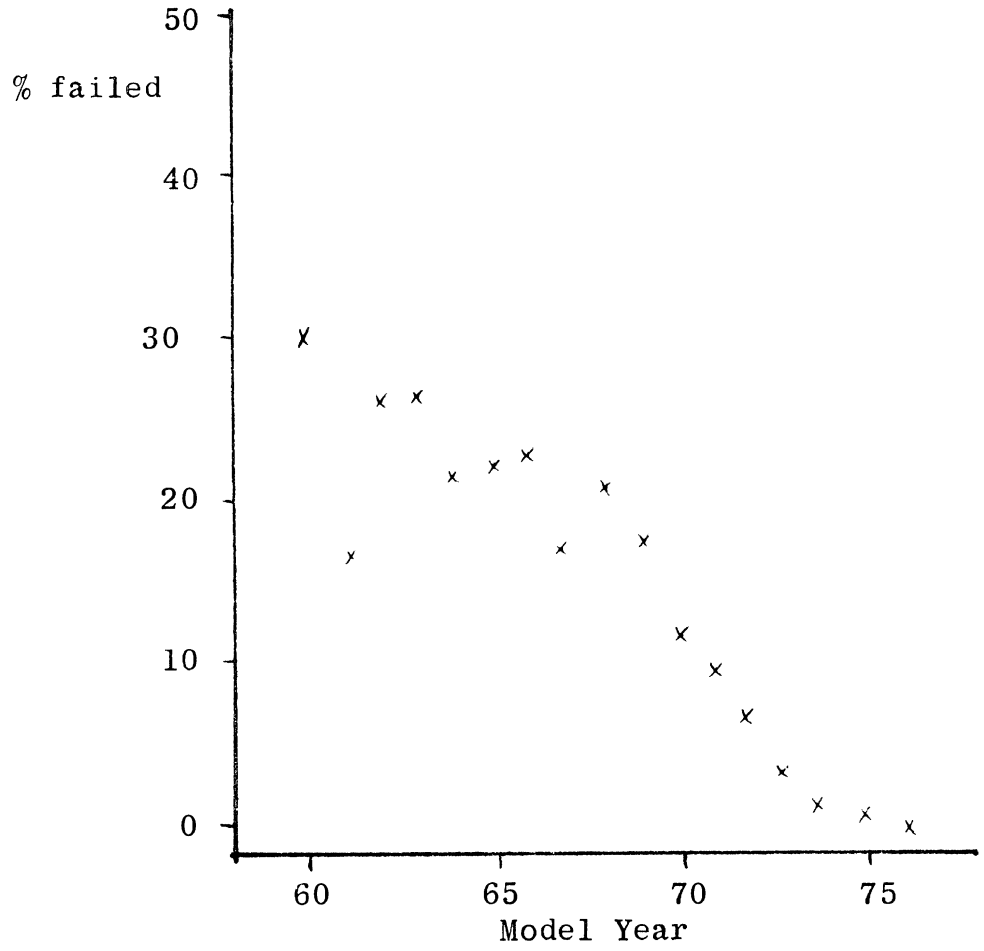
Figure B-20



Year	Total	Failed	% Failing
1960	10	4	40.0
1961	12	3	25.0
1962	42	10	23.8
1963	53	18	34.0
1964	144	40	27.8
1965	270	79	29.3
1966	385	96	24.9
1967	552	126	22.8
1968	748	179	23.9
1969	1023	195	19.1
1970	981	141	14.4
1971	1169	157	13.4
1972	1712	200	11.7
1973	1998	175	8.8
1974	1890	81	4.3
1975	1299	4	0.3
1976	27	0	0.0
Total	12315	1508	12.2

Figure B-21

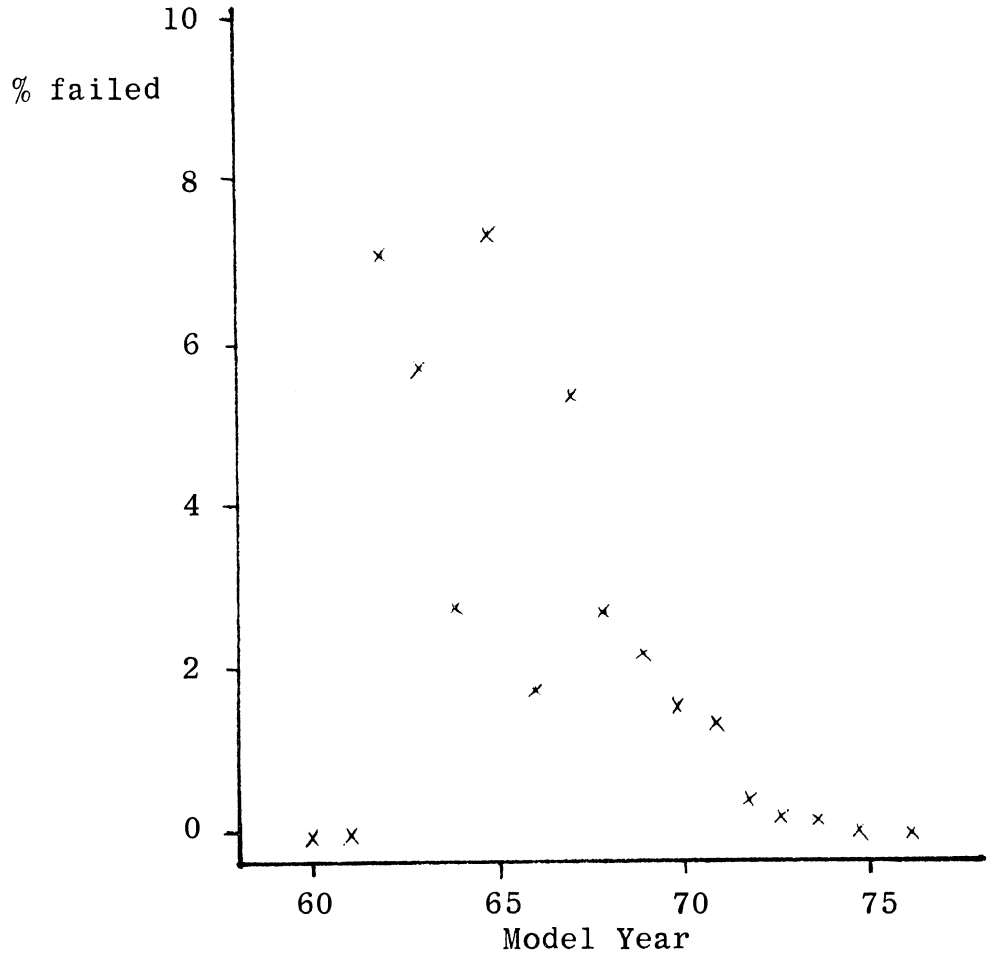
Exhaust Noise



Year	Total	Failed	% Failing
1960	10	3	30.0
1961	12	2	16.7
1962	42	11	26.2
1963	53	14	26.4
1964	144	31	21.5
1965	270	60	22.2
1966	385	88	22.9
1967	552	94	17.0
1968	748	156	20.9
1969	1023	179	17.5
1970	981	115	11.7
1971	1169	112	6.7
1972	1712	114	3.3
1973	1998	65	1.2
1974	1890	22	0.6
1975	1299	8	0.0
1976	27	0	
Total	12315	1074	8.7

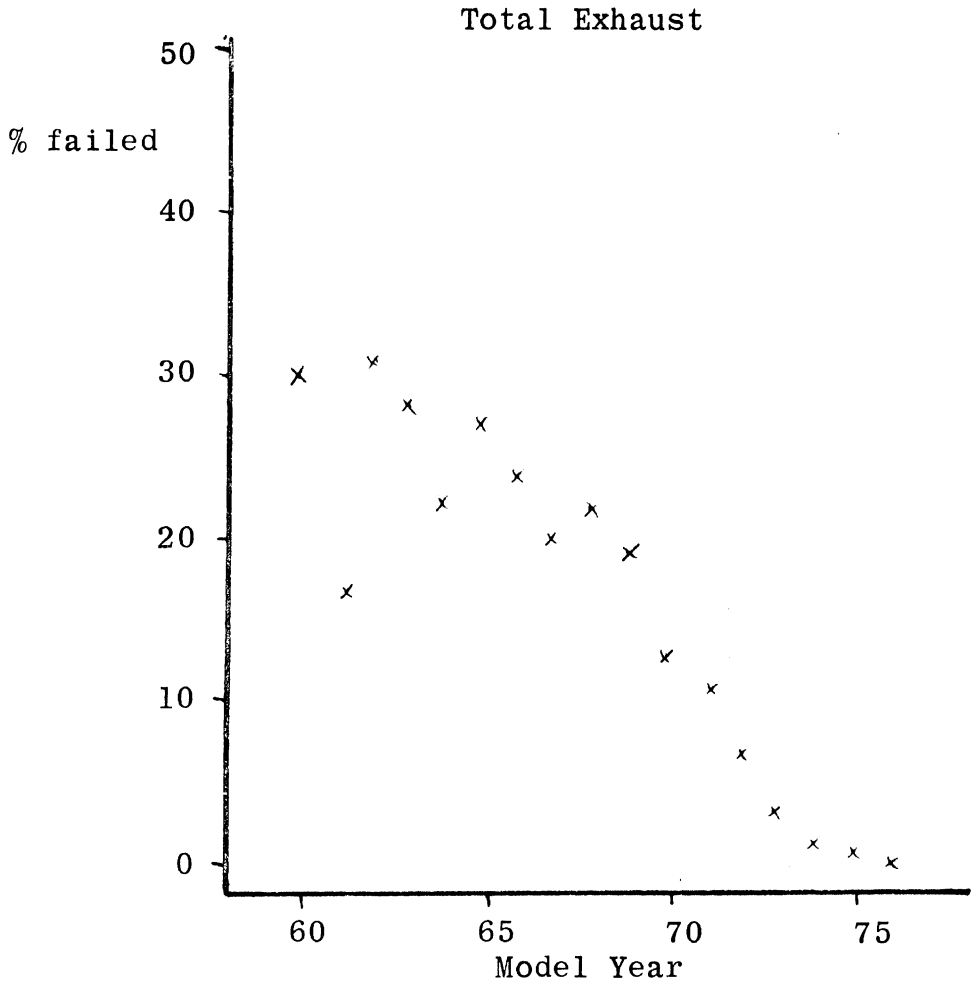
Figure B-22

Exhaust Smoke



Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	0	0.0
1962	42	3	7.1
1963	53	3	5.7
1964	144	4	2.8
1965	270	20	7.4
1966	385	7	1.8
1967	552	30	5.4
1968	748	20	2.7
1969	1023	23	2.2
1970	981	16	1.6
1971	1169	16	1.4
1972	1712	7	0.4
1973	1998	4	0.2
1974	1890	3	0.2
1975	1299	0	0.0
1976	27	0	0.0
Total	12315	156	1.3

Figure B-23



Year	Total	Failed	% Failing
1960	10	3	30.0
1961	12	2	16.7
1962	42	13	31.6
1963	53	15	28.3
1964	144	32	22.2
1965	270	73	27.0
1966	385	92	23.9
1967	552	110	19.9
1968	748	164	21.9
1969	1023	193	18.9
1970	981	127	12.9
1971	1169	124	10.6
1972	1712	118	6.9
1973	1998	67	3.4
1974	1890	24	1.3
1975	1299	8	0.6
1976	27	0	0.0
Total	12315	1165	9.5

Figure B-24

Table B-11

DRIVER INTERVIEW DATA

	Monroe Count	%	Jackson Count	%	Total Count	%
AGE OF DRIVER						
15-20	38	12.2	244	13.0	282	12.9
20-25	49	15.7	257	13.7	306	14.0
25-30	42	13.5	228	12.1	270	12.3
30-35	39	12.5	195	10.4	234	10.7
35-40	27	8.7	172	9.2	199	9.1
40-45	23	7.4	141	7.5	164	7.5
45-50	28	9.0	143	7.6	171	7.8
50-55	19	6.1	120	6.4	139	6.3
55-60	18	5.8	109	5.8	127	5.8
60-65	10	3.2	105	5.6	115	5.3
65-70	10	3.2	94	5.0	104	4.7
70-75	6	1.9	48	2.6	54	2.5
75	3	0.9	22	1.2	25	1.1
Total	312		1878		2190	
Missing	4		37		41	
SEX OF DRIVER						
Male	189	60.2	1071	56.3	1260	56.9
Female	125	39.8	831	43.7	956	43.1
Total	314		1902		2216	
Missing	2		13		15	
QUESTION #1						
Response						
1	22	7.1	68	3.7	90	4.2
2	107	34.5	485	26.2	592	27.4
3*	158	51.0	1179	63.6	1337	61.8
4	23	7.4	121	6.5	144	6.6
Total	310		1853		2163	
Missing	6		62		68	
QUESTION #2						
Response						
1	16	5.1	85	4.5	101	4.6
2	57	18.3	273	14.6	330	15.1
3	84	27.0	373	20.0	457	21.0
4*	109	35.0	913	48.8	1022	46.9
5	45	14.5	225	12.0	270	12.4
Total	311		1869		2180	
Missing	5		46		51	
QUESTION #3						
Response						
1	41	13.4	148	8.0	189	8.7
2	160	52.1	1383	74.6	1543	71.4
3	1	0.3	23	1.2	24	1.1
4	59	19.2	191	10.3	250	11.6
5	23	7.5	74	4.0	97	4.5
6	23	7.5	35	1.9	58	2.7
Total	307		1854		2161	
Missing	9		61		70	

* denotes correct response

Table B-11 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
QUESTION #4						
Response						
1	30	9.6	63	3.4	93	4.3
2	282	90.4	1811	96.6	2093	95.7
Total	312		1874		2186	
Missing	4		41		45	
QUESTION #5						
Response						
1	21	6.7	168	9.0	189	8.6
2	51	16.3	249	13.3	300	13.7
3	66	21.2	447	23.8	513	23.4
4	70	22.4	423	22.5	493	22.5
5	62	19.9	263	14.0	325	14.8
6	42	13.5	367	19.7	409	18.7
Total	312		1877		2189	
Missing	4		38		42	
QUESTION #6						
Response						
1	52	16.8	56	21.1	108	18.8
2	69	22.3	71	26.7	140	24.3
3	122	39.5	91	34.2	213	37.0
4	66	21.4	48	18.0	114	19.8
Total	309		266		575	
Missing	7		1649		1656	
QUESTION #7						
Response						
1	53	17.8	46	17.8	99	17.8
2	142	47.8	101	39.0	243	43.7
3	102	34.3	112	43.2	214	38.5
Total	297		259		556	
Missing	19		1656		1675	
QUESTION #8						
Response						
Agree	208	67.3	183	69.3	391	68.2
Disagree	28	9.1	20	7.6	48	8.4
No Opinion	73	23.6	61	23.1	134	23.4
Total	309		264		573	
Missing	7		1651		1658	

Table B-11 Continued

	Monroe Count	Monroe %	Jackson Count	Jackson %	Total Count	Total %
QUESTION #9						
Response						
Agree	262	84.5	242	91.3	504	87.7
Disagree	33	10.6	14	5.3	47	8.2
No Opinion	15	4.8	9	3.4	24	4.2
Total	310		265		575	
Missing	6		1650		1656	
QUESTION #10						
Response						
Agree	97	31.3	77	29.1	174	30.3
Disagree	181	58.4	158	59.6	339	59.0
No Opinion	32	10.3	30	11.3	62	10.7
Total	310		265		575	
Missing	6		1650		1656	
QUESTION #11						
Response						
Agree	41	13.2	45	16.9	86	14.9
Disagree	237	76.2	196	73.7	433	75.0
No Opinion	33	10.6	25	9.4	58	10.1
Total	311		266		577	
Missing	5		1649		1654	
QUESTION #12						
Agree	174	55.9	141	53.0	315	54.6
Disagree	96	30.9	90	33.8	186	32.2
No Opinion	41	13.2	35	13.2	76	13.2
Total	311		266		577	
Missing	5		1649		1654	
COMPLETION PROBLEMS						
None	306	96.8	1858	97.0	2164	97.0
Refused	1	0.3	1	0.1	2	0.1
Illiterate	5	1.6	10	0.5	15	0.7
No Reading Glasses	0	0.0	4	0.2	4	0.2
Mentally/Physically Incapable	1	0.3	9	0.5	10	0.4
Other	3	0.9	33	1.7	36	1.6
Total	316		1915		2231	

Table B-11 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
INTERVIEWER						
R. Copp	162	54.0	421	22.7	583	27.0
R. Corn	138	46.0	445	24.0	583	27.0
J.P. Monson	0	0.0	29	1.6	29	1.3
M. Sackett	0	0.0	1	0.1	1	0.1
M. Todd	0	0.0	961	51.8	961	44.6
Total	300		1857		2157	
Missing	16		58		74	

Table B-12

MOVING-STOPPING TEST VARIABLES

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
WHEEL PULL						
Yes	287	16.1	2004	20.3	2291	19.7
No	1499	83.9	7861	79.7	9360	80.3
Total	1786		9865		11651	
PEDAL PRESSURE						
Pass	1660	92.9	9275	94.0	10935	93.9
Soft Pedal	44	2.5	65	0.7	109	0.9
Low pedal	38	2.1	182	1.8	220	1.9
Pressure loss	0	0.0	3	0.0	3	0.0
Complete loss	1	0.1	14	0.1	15	0.1
Hard Pedal	21	1.2	50	0.5	71	0.6
Pulsating pedal	18	1.0	57	0.6	75	0.6
Refused	4	0.2	219	2.2	223	1.9
Total	1786		9865		11651	

Table B-12 Continued

	Monroe Count	Monroe %	Jackson Count	Jackson %	Total Count	Total %
STOPPING TEST						
Pass	1570	87.9	8908	90.3	10478	89.9
Cannot stop	13	0.7	92	0.9	105	0.9
Side to side	192	10.8	629	6.4	821	7.0
Both	7	0.4	17	0.2	24	0.2
Refused	4	0.2	220	2.2	224	1.9
Total	1786		9865		11651	
STOPPING AUDIBLE						
Pass	1574	88.1	8967	90.9	10541	90.5
Fail	208	11.6	678	6.9	886	7.6
Refused	4	0.2	220	2.2	224	1.9
Total	1786		9865		11651	
TOTAL STOPPING DEFECTS						
number						
o	1340	75.0	8195	83.1	9535	81.8
1	358	20.0	1173	11.9	1531	13.1
2	68	3.8	217	2.2	285	2.4
3	16	0.9	60	0.6	76	0.7
Refused	4	0.2	220	2.2	224	1.9
Total	1786		9865		11651	
TOTAL INSPECTION DEFECTS						
0	747	41.8	4728	47.9	5475	47.0
1	438	24.5	2126	21.6	2564	22.0
2	238	13.3	1252	12.7	1490	12.8
3	156	8.7	730	7.4	886	7.6
4	92	5.2	421	4.3	513	4.4
5	46	2.6	231	2.3	277	2.4
6	33	1.8	163	1.7	196	1.7
7	17	1.0	82	0.8	99	0.8
8	9	0.5	49	0.5	58	0.5
9	3	0.2	39	0.4	42	0.4
10	4	0.2	18	0.2	22	0.2
>10	3	0.2	26	0.3	29	0.2
Total	1786		9865		11651	

Table B-13

WHEEL PULL VARIABLES

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
BRAKE INSPECTION						
No	1487	83.3	7847	79.5	9334	80.1
Yes	299	16.7	2018	20.5	2317	19.9
Total	1786		9865		11651	
INTERVIEW						
Yes	316	17.7	1915	19.4	2231	19.1
No	1470	82.3	7950	80.6	9420	80.9
Total	1786		9865		11651	
BRAKE INSPECTOR						
M. Huber	17	5.7	0	0.0	17	0.7
J.P. Monson	173	57.9	105	5.2	275	11.9
M. Sackett	40	13.4	24	1.2	64	2.8
M. Todd	69	23.1	1888	93.6	1952	84.3
Total	299		201		2316	
Missing	1487		7848		9335	
BRAKE TYPE						
Power-disc	112	37.5	828	41.1	940	40.6
Non-power disc	35	11.7	142	7.0	177	7.6
Power-drum	43	14.4	404	20.0	447	19.3
Non-power drum	101	33.8	607	30.1	708	30.6
Incomplete code	8	2.7	35	1.8	43	1.9
Total	299		2016		2315	
Missing	0		2		2	
MASTER CYLINDER FLUID						
Full	228	78.6	1745	88.0	1973	86.8
Half	50	17.2	163	8.2	213	9.4
Low	12	4.1	74	3.7	86	3.8
Total	290		1982		2272	
Missing	9		36		45	
BRAKE FLUID QUALITY						
Pass	290	99.7	1963	99.0	2253	99.1
Fail	1	0.3	19	1.0	20	0.9
Total	291		1982		2273	
Missing	8		36		45	
VACUUM HOSE						
Pass	295	100.0	1978	100.0	2273	100.0
Fail	0	0.0	0	0.0	0	0.0
Total	295		1978		2273	
Missing	4		40		44	

Table B-13 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
WHEEL BEARING GREASE						
Pass	266	89.9	1918	95.5	2184	94.7
Fail	3	1.0	2	0.1	5	0.2
Unable to inspect	27	9.1	88	4.4	115	5.0
Total	296		2008		2306	
Missing	3		10		13	
WHEEL PULL						
Yes	238	80.1	1865	93.3	2103	91.6
Unable to pull	59	19.9	134	6.7	193	8.4
Total	297		1999		2296	
Missing	2		19		21	
SHOE-PAD CONDITION						
75-100%	195	82.3	1490	79.7	1685	80.0
50-75%	29	12.2	182	9.7	211	10.0
1/32"-50%	10	4.2	114	6.1	124	5.9
Fail	3	1.3	83	4.4	86	4.1
Total	237		1869		2106	
Missing	62		149		211	
ROTOR OR DRUM						
Pass	215	91.1	1687	90.6	1902	90.7
Cracked	0	0.0	3	0.2	3	0.1
Worn	11	4.7	17	0.9	28	1.3
Grooves	10	4.2	155	8.3	165	7.9
Total	236		1862		2098	
Missing	63		156		219	
BRAKE HARDWARE						
Pass	237	100.0	1865	100.0	2102	100.0
Springs	0	0.0	0	0.0	0	0.0
Retainer	0	0.0	0	0.0	0	0.0
Self-adjuster	0	0.0	0	0.0	0	0.0
Total	237		1865		2102	
Missing	62		153		215	
WHEEL CYLINDERS						
Pass	227	96.6	1853	99.6	2080	99.3
Fail	8	3.4	7	0.4	15	0.7
Total	235		1860		2095	
Missing	64		158		222	

APPENDIX C

DETAILED DATA TABULATIONS - 1976

Table C-1

Vehicle Manufacturer

	Jackson	Monroe	Michigan
AMC	161	68	134,255
Ford	1291	612	1,097,989
Chrysler	697	273	657,744
GM	3354	825	2,177,058

Chi-square test of homogeneity

	X^2	Significance
Jackson - Michigan	8197.86	0.0
Jackson - Monroe	122.066	0.0
Monroe - Michigan	2422.474	0.0

Table C-2

Vehicle Age

Age	Newly inspected Jackson	Monroe	Sample Total	Michigan
1	574	152	726	407,915
2	578	205	783	407,814
3	753	272	1025	507,774
4	890	288	1178	575,210
5	758	271	1029	496,810
6	625	174	799	401,490
7	580	183	763	346,579
8	605	175	780	330,422
9	496	137	633	280,011
10	352	93	445	195,622
11	225	72	297	150,889
12	164	59	223	110,903
13+	168	56	224	632,362

Chi-square test of Homogeneity

Comparison	X^2	Significance
Jackson - Michigan	719.954	0.0
Monroe - Michigan	229.509	0.0
Total Sample - Michigan	926.126	0.0
Jackson - Monroe	20.959	0.0510

Table C-3

Vehicle Type

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
Full Size	919	43.6	4225	46.4	5144	45.9
Intermediate	722	34.3	2942	32.3	3664	32.7
Compact	152	7.2	503	5.5	655	5.8
Sports Car	10	0.5	69	0.8	79	0.7
Station bus, Carryall	75	3.6	192	2.1	267	2.4
Jeep	12	0.6	40	0.4	1334	11.9
Pickup or Panel	216	10.3	1118	12.3	1334	11.9
Total	2106		9097		11203	
Missing	33		190		223	

Chi-square test of homogeneity

χ^2 = 36.834 significance level = 0.0000

Table C-4

Vehicle Mileage
(thousands of miles)

Mileage	Monroe Count	Monroe %	Jackson Count	Jackson %	Total Count	Total %
0-10	164	9.7	497	5.4	661	5.8
10-20	177	8.3	750	8.1	927	8.2
20-30	191	19.0	879	9.5	1070	9.4
30-40	253	11.9	1012	11.0	1265	11.1
40-50	253	11.9	1104	12.0	1357	11.9
50-60	243	11.4	1048	11.3	1291	11.4
60-70	210	9.9	1017	11.0	1227	10.8
70-80	202	9.5	902	9.8	1104	9.7
80-90	171	8.0	694	7.5	865	7.6
90-100	87	4.1	516	5.6	603	5.3
100-110	75	3.5	353	3.8	428	3.8
110-120	48	2.3	213	2.3	261	2.3
120-130	19	0.9	122	1.3	141	1.2
130-140	14	0.7	61	0.7	75	0.7
140-150	7	0.3	34	0.4	41	0.4
150-160	5	0.2	12	0.1	17	0.1
>160	6	0.3	23	0.2	29	0.3
Total	2125		9237		11362	

Chi-square test of homogeneity*

$\chi^2 = 30.697$ significance level = .0022

*Due to small numbers vehicles with over 120,000 miles were collapsed into one category

Table C-5

Vehicle Year

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
Pre 1960	4	0.2	19	0.2	23	0.2
1960	4	0.2	13	0.1	17	0.1
1961	3	0.1	13	0.1	16	0.1
1962	3	0.1	27	0.3	30	0.3
1963	17	0.8	38	0.4	55	0.5
1964	25	1.2	93	1.0	118	1.0
1965	59	2.8	119	2.1	258	2.3
1966	72	3.4	267	2.9	339	3.0
1967	93	4.3	430	4.6	523	4.6
1968	137	6.4	614	6.6	751	6.6
1969	176	8.2	770	8.3	946	8.3
1970	183	8.6	770	8.3	953	8.3
1971	174	8.1	889	9.6	1063	9.3
1972	271	12.7	1103	11.9	1374	12.0
1973	288	13.5	1357	14.6	1645	14.4
1974	272	12.7	1180	12.7	1452	12.7
1975	206	9.6	917	9.9	1123	9.8
1976	152	7.1	588	6.3	740	6.5
Total	2139		9287		11426	

Chi-square test for homogeneity*

χ^2 = 20.604 significance level = .2445

Table C-6

Vehicle Make

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
Passenger Cars						
AMC	68	3.2	221	2.4	289	3.6
Buick	94	4.5	715	7.9	809	7.2
Cadillac	17	0.8	120	1.3	137	1.2
Chevrolet	409	19.5	2110	23.3	2519	22.6
Chrysler	41	2.0	128	1.4	169	1.5
Dodge	84	4.0	389	4.3	473	4.2
Ford	483	23.0	1389	15.3	1872	16.8
Imperial	1	0.0	4	0.0	5	0.0
Jeep	3	0.1	28	0.3	31	0.3
Lincoln	13	0.6	34	0.4	47	0.4
Mercury	117	5.6	339	3.7	456	4.1
Oldsmobile	177	8.4	811	9.0	988	8.9
Plymouth	147	7.0	436	4.8	583	5.2
Pontiac	129	6.1	858	9.5	987	8.8
Volkswagen	30	1.4	105	1.2	135	1.2
Other	38	1.8	180	2.0	218	1.9
Trucks						
Chevrolet	90	4.3	488	5.4	578	5.2
Dodge	30	1.4	121	1.3	151	1.4
Ford	99	4.7	457	5.0	556	5.0
GMC	10	0.5	88	1.0	98	0.9
International	13	0.6	29	0.3	42	0.4
Willys	5	0.2	9	0.1	14	0.1

Chi-square test for homogeneity

χ^2=192.05 significance level = 0.0

Table C-7

Total Vehicle

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
Pass	813	38.0	4219	45.4	5032	44.0
Fail	1326	62.0	5068	54.6	6394	56.0
Total	2139		9287		11426	

Chi-square test of homogeneity

χ^2=38.847 significance level = 0.0

Table C-8 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	5
WIPERS OR WASHERS						
Pass	1622	75.8	7616	82.0	9238	80.9
Fail	517	24.2	1671	18.0	2188	19.1
Total	2139		9287		11426	
MIRROR						
Pass	2048	95.7	8950	96.4	10998	96.3
Fail	91	4.3	337	3.6	428	3.7
Total	2139		9287		11426	
TOTAL VISION DEFECTS						
0	1523	71.2	7219	77.7	8742	76.5
1	506	23.7	1611	17.3	2117	18.5
2	96	4.5	396	4.3	492	4.3
3	13	0.6	50	0.5	63	0.6
4	1	0.0	11	0.1	12	0.1
Total	2139		9287		11426	
FRONT DIRECTIONAL LIGHTS						
Pass	2023	94.6	8759	94.3	10782	94.4
Fail	116	5.4	528	5.7	644	5.6
Total	2139		9287		11426	
HIGH BEAM						
Pass	1933	90.4	8427	90.7	10360	90.7
Fail	206	9.6	860	9.3	1066	9.3
Total	2139		9287		11426	
LOW BEAM						
Pass	2080	97.2	8961	96.5	11041	96.6
Fail	59	2.8	326	3.5	385	3.4
Total	2139		9287		11426	

Table C-8 Continued

	Monroe Count	Monroe %	Jackson Count	Jackson %	Total Count	Total 5
WIPERS OR WASHERS						
Pass	1622	75.8	7616	82.0	9238	80.9
Fail	517	24.2	1671	18.0	2188	19.1
Total	2139		9287		11426	
MIRROR						
Pass	2048	95.7	8950	96.4	10998	96.3
Fail	91	4.3	337	3.6	428	3.7
Total	2139		9287		11426	
TOTAL VISION DEFECTS						
0	1523	71.2	7219	77.7	8742	76.5
1	506	23.7	1611	17.3	2117	18.5
2	96	4.5	396	4.3	492	4.3
3	13	0.6	50	0.5	63	0.6
4	1	0.0	11	0.1	12	0.1
Total	2139		9287		11426	
FRONT DIRECTIONAL LIGHTS						
Pass	2023	94.6	8759	94.3	10782	94.4
Fail	116	5.4	528	5.7	644	5.6
Total	2139		9287		11426	
HIGH BEAM						
Pass	1933	90.4	8427	90.7	10360	90.7
Fail	206	9.6	860	9.3	1066	9.3
Total	2139		9287		11426	
LOW BEAM						
Pass	2080	97.2	8961	96.5	11041	96.6
Fail	59	2.8	326	3.5	385	3.4
Total	2139		9287		11426	

Table C-8 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
PLATE LIGHT						
Pass	1699	79.4	7563	81.4	9262	81.1
Fail	440	20.6	1724	18.6	2164	13.9
Total	2139		9287		11426	
BEAM INDICATOR						
Pass	2139	100.0	9285	100.0	11424	100.0
Fail	0	0.0	2	0.0	2	0.0
Total	2139		9287		11426	
TOTAL LIGHTS						
Pass	1313	61.6	5855	63.0	7173	62.8
Fail	821	38.4	3432	37.0	4253	37.2
Total	2139		9287		11426	
MAJOR LIGHT DEFECTS						
0	1360	76.2	7070	76.1	8700	76.1
1	292	13.7	1141	12.3	1433	12.5
2	117	5.5	584	6.3	701	6.1
3	68	3.2	310	3.3	156	1.4
4	23	1.1	133	1.4	58	0.5
>4	9	0.4	49	0.5	58	0.5
Total	2139		9287		11426	
TOTAL LIGHT DEFECTS						
0	1318	61.6	5855	63.0	7173	62.8
1	489	22.9	1940	20.9	2429	21.3
2	182	8.5	767	8.3	949	8.3
3	83	3.9	391	4.2	474	4.1
4	40	1.9	200	2.2	240	2.1
5	20	0.9	90	1.0	110	1.0
>5	7	0.3	44	0.5	51	0.5
Total	2139		9287		11426	

Table C-8 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
PLATE LIGHT						
Pass	1699	79.4	7563	81.4	9262	81.1
Fail	440	20.6	1724	18.6	2164	18.9
Total	2139		9287		11426	
BEAM INDICATOR						
Pass	2139	100.0	9285	100.0	11424	100.0
Fail	0	0.0	2	0.0	2	0.0
Total	2139		9287		11426	
TOTAL LIGHTS						
Pass	1313	61.6	5855	63.0	7173	62.8
Fail	821	38.4	3432	37.0	4253	37.2
Total	2139		9287		11426	
MAJOR LIGHT DEFECTS						
0	1360	76.2	7070	76.1	8700	76.1
1	292	13.7	1141	12.3	1433	12.5
2	117	5.5	584	6.3	701	6.1
3	68	3.2	310	3.3	156	1.4
4	23	1.1	133	1.4	58	0.5
>4	9	0.4	49	0.5	58	0.5
Total	2139		9287		11426	
TOTAL LIGHT DEFECTS						
0	1318	61.6	5855	63.0	7173	62.8
1	489	22.9	1940	20.9	2429	21.3
2	182	8.5	767	8.3	949	8.3
3	83	3.9	391	4.2	474	4.1
4	40	1.9	200	2.2	240	2.1
5	20	0.9	90	1.0	110	1.0
>5	7	0.3	44	0.5	51	0.5
Total	2139		9287		11426	

Table C-8 Continued

	Monroe Count	Monroe %	Jackson Count	Jackson %	Total Count	Total %
TIRE TREAD						
Pass	1666	77.9	7657	82.4	9323	81.6
Fail	473	22.1	1630	17.6	2103	18.4
Total	2139		9287		11426	
TIRES, OVERALL						
Pass	1665	77.8	7652	82.4	9317	81.5
Fail	474	22.2	1635	17.6	2109	18.5
Total	2139		9287		11426	
CONTROL DEFECTS						
0	1650	77.1	7606	81.9	9256	81.0
1	469	21.9	1590	17.1	2059	18.0
2	17	0.8	90	1.0	107	0.9
3	3	0.1	1	0.0	4	0.0
Total	2139		9287		11426	
EXHAUST NOISE						
Pass	1804	34.3	7823	84.2	9627	84.3
Fail	335	15.7	1464	15.8	1799	15.7
Total	2139		9287		11426	
EXHAUST SMOKE						
Pass	2101	98.2	9133	98.3	11234	98.3
Fail	38	1.8	154	1.7	192	1.7
Total	2139		9287		11426	
TOTAL EXHAUST						
Pass	1782	83.3	7735	83.3	9517	83.3
Fail	357	16.7	1552	16.7	1909	16.7
Total	2139		9287		11426	

Table C-8 Continued

	Monroe Count	Monroe %	Jackson Count	Jackson %	Total Count	Total %
TIRE TREAD						
Pass	1666	77.9	7657	82.4	9323	81.6
Fail	473	22.1	1630	17.6	2103	18.4
Total	2139		9287		11426	
TIRES, OVERALL						
Pass	1665	77.8	7652	82.4	9317	81.5
Fail	474	22.2	1635	17.6	2109	18.5
Total	2139		9287		11426	
CONTROL DEFECTS						
0	1650	77.1	7606	81.9	9256	81.0
1	469	21.9	1590	17.1	2059	18.0
2	17	0.8	90	1.0	107	0.9
3	3	0.1	1	0.0	4	0.0
Total	2139		9287		11426	
EXHAUST NOISE						
Pass	1804	34.3	7823	84.2	9627	84.3
Fail	335	15.7	1464	15.8	1799	15.7
Total	2139		9287		11426	
EXHAUST SMOKE						
Pass	2101	98.2	9133	98.3	11234	98.3
Fail	38	1.8	154	1.7	192	1.7
Total	2139		9287		11426	
TOTAL EXHAUST						
Pass	1782	83.3	7735	83.3	9517	83.3
Fail	357	16.7	1552	16.7	1909	16.7
Total	2139		9287		11426	

Table C-8 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
TOTAL MECHANICAL						
0	856	40.0	4354	46.9	5210	45.6
1	480	22.4	1759	18.9	2239	19.6
2	350	16.4	1360	14.6	1710	15.0
3	205	9.6	723	7.8	928	8.1
4	97	4.5	422	4.5	519	4.5
5	60	2.8	278	3.0	338	3.0
6	40	1.9	173	1.9	213	1.9
7	25	1.2	110	1.2	135	1.2
8	11	0.5	55	0.6	66	0.6
9	9	0.4	29	0.3	38	0.3
10	3	0.1	12	0.1	15	0.1
11	3	0.1	8	0.1	11	0.1
12	0	0.0	4	0.0	4	0.0
Total	2139		9287		11426	
TOTAL VEHICLE						
Pass	813	38.0	4219	45.4	5032	44.0
Fail	1326	62.0	5068	54.6	6394	56.0
Total	2139		9287		11426	
SUMMONS ISSUED						
0	1954	98.1	8581	97.5	10535	97.6
1	36	1.8	214	2.4	250	2.3
2	1	0.1	6	0.1	7	0.1
Miscode	148		485		633	
Total	1991		8802		10793	
SEAT BELTS						
Yes	462	21.6	3159	34.0	3621	31.7
No	1677	78.4	6125	66.0	7802	68.3
Total	2139		9284		11423	

Table C-8 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
TOTAL MECHANICAL						
0	856	40.0	4354	46.9	5210	45.6
1	480	22.4	1759	18.9	2239	19.6
2	350	16.4	1360	14.6	1710	15.0
3	205	9.6	723	7.8	928	8.1
4	97	4.5	422	4.5	519	4.5
5	60	2.8	278	3.0	338	3.0
6	40	1.9	173	1.9	213	1.9
7	25	1.2	110	1.2	135	1.2
8	11	0.5	55	0.6	66	0.6
9	9	0.4	29	0.3	38	0.3
10	3	0.1	12	0.1	15	0.1
11	3	0.1	8	0.1	11	0.1
12	0	0.0	4	0.0	4	0.0
Total	2139		9287		11426	
TOTAL VEHICLE						
Pass	813	38.0	4219	45.4	5032	44.0
Fail	1326	62.0	5068	54.6	6394	56.0
Total	2139		9287		11426	
SUMMONS ISSUED						
0	1954	98.1	8581	97.5	10535	97.6
1	36	1.8	214	2.4	250	2.3
2	1	0.1	6	0.1	7	0.1
Miscode	148		485		633	
Total	1991		8802		10793	
SEAT BELTS						
Yes	462	21.6	3159	34.0	3621	31.7
No	1677	78.4	6125	66.0	7802	68.3
Total	2139		9284		11423	

Table C-9

Pedal Pressure Test

Age	Count	Pass	Pedal Soft	Low Pedal	Pressure Loss	Hard Pedal	Pulsating Pedal
1	556	100.0	0.0	0.0	0.0	0.0	0.0
2	949	99.7	0.0	0.2	0.0	0.0	0.1
3	1212	99.2	0.1	0.2	0.1	0.1	0.3
4	1413	99.2	0.1	0.1	0.2	0.2	0.2
5	1180	98.3	0.1	0.4	0.0	0.5	0.7
6	905	96.4	0.0	1.2	0.1	1.0	1.3
7	816	95.7	0.2	2.2	0.4	1.1	0.4
8	809	94.6	0.6	3.6	0.2	0.6	0.4
9	644	93.4	0.3	4.5	0.3	1.2	0.3
10	430	93.4	0.5	4.7	0.2	0.7	0.5
11	282	93.2	1.4	3.9	0.4	0.7	0.4
12	210	92.7	1.0	4.8	1.0	0.5	0.0
13	100	91.0	0.0	5.0	2.0	1.0	1.0
14	45	91.1	0.0	6.7	2.2	0.0	0.0
15	25	76.0	0.0	20.0	0.0	4.0	0.0
16	11	90.9	0.0	0.0	0.0	0.0	9.1
17+	30	83.4	0.0	3.3	3.3	10.0	0.0
Total	9617	97.0	0.2	1.7	0.2	0.5	0.4

Table C-10

Stopping Test

Age	Count	Pass	Cannot Stop	Side-to-Side	Both
1	556	100.0	0.0	0.0	0.0
2	949	99.2	0.0	0.8	0.0
3	1212	97.8	0.1	2.1	0.0
4	1413	96.7	0.1	3.2	0.0
5	1180	96.7	0.1	3.0	0.2
6	905	94.6	0.4	5.0	0.0
7	816	90.8	0.9	8.2	0.1
8	809	89.2	0.1	10.6	0.1
9	644	86.7	0.3	12.4	0.6
10	430	86.2	0.5	12.8	0.5
11	282	82.9	1.1	16.0	0.0
12	210	80.0	1.9	17.1	1.0
13	100	82.0	3.0	15.0	0.0
14	45	86.7	0.0	13.3	0.0
15	25	68.0	0.0	28.0	4.0
16	11	100.0	0.0	0.0	0.0
17+	30	76.7	3.3	20.0	0.0
Total	9617	93.8	0.3	5.8	0.1

Table C-11

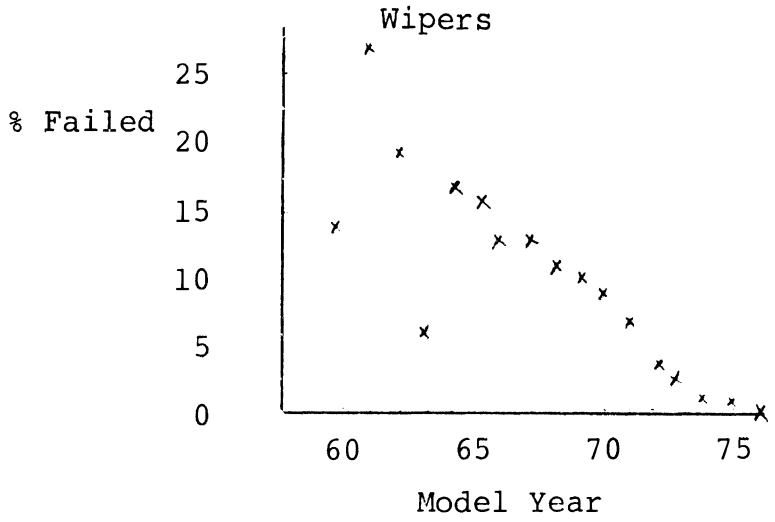
Stopping Audible

Age	Count	Pass	Fail
1	556	100.0	0.0
2	949	99.3	0.7
3	1212	97.0	3.0
4	1413	95.4	4.6
5	1180	95.2	4.8
6	905	93.7	6.3
7	816	91.9	8.1
8	809	90.0	10.0
9	644	87.6	12.4
10	430	86.3	13.7
11	282	86.5	13.5
12	210	81.4	18.6
13	100	86.0	14.0
14	45	88.9	11.1
15	25	80.0	20.0
16	11	100.0	0.0
17+	30	86.7	13.3
Total	9617	93.6	6.4

Table C-12

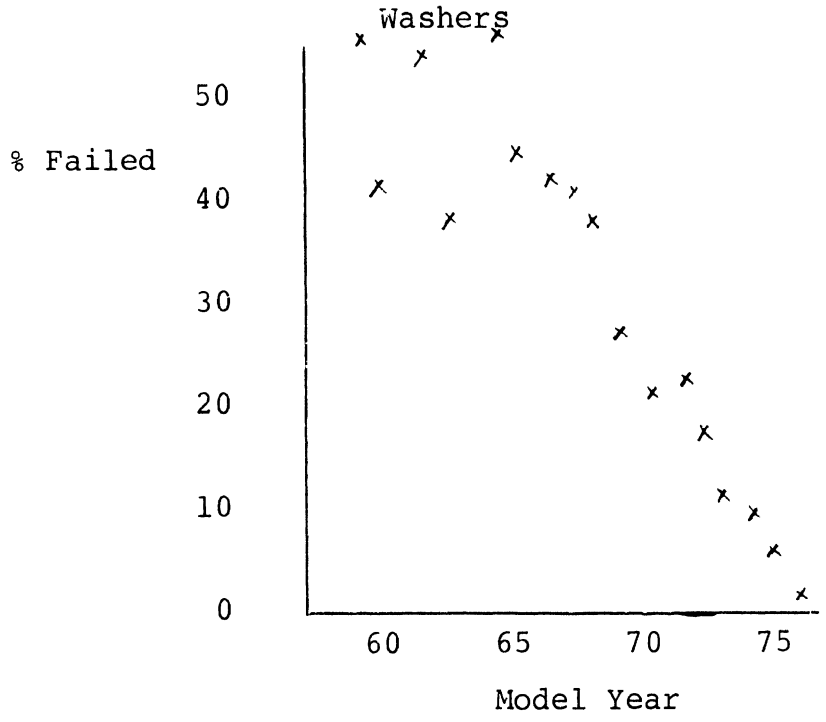
Number of Stopping Defects

Age	Count	0	1	2	3
1	556	100.0	0.0	0.0	0.0
2	949	98.1	1.9	0.0	0.0
3	1212	94.3	5.4	0.3	0.0
4	1413	92.2	7.1	0.6	0.1
5	1180	90.4	8.6	0.7	0.3
6	905	96.9	11.3	1.5	0.3
7	816	82.3	14.7	2.0	1.0
8	809	77.8	18.8	2.8	0.6
9	644	73.8	21.4	3.4	1.4
10	430	74.1	19.8	4.0	2.1
11	282	72.4	20.2	5.3	2.1
12	210	65.3	25.7	7.1	1.9
13	100	61.0	20.0	6.0	3.0
14	45	71.2	24.4	4.4	0.0
15	25	52.0	24.0	20.0	4.0
16	11	90.9	9.1	0.0	0.0
17+	30	60.1	26.2	13.3	0.0
Total	9617	86.9	10.8	1.7	0.6



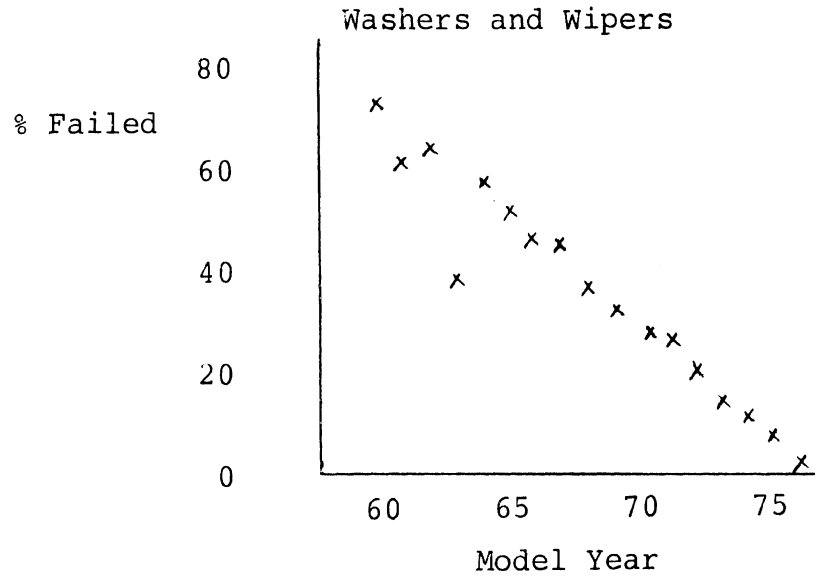
	Year	Total	Failed	% Failing
pre	1960	20	6	30.0
	1960	14	2	14.3
	1961	15	4	26.7
	1962	26	5	19.2
	1963	49	3	6.1
	1964	100	17	17.0
	1965	223	34	15.2
	1966	297	33	11.1
	1967	445	51	11.5
	1968	633	65	10.3
	1969	780	71	9.1
	1970	763	60	7.9
	1971	799	52	6.5
	1972	1029	34	3.3
	1973	1178	25	2.1
	1974	1025	9	0.9
	1975	783	4	0.5
	1976	726	0	0.0
	Total	8905	475	5.3

Figure C-1



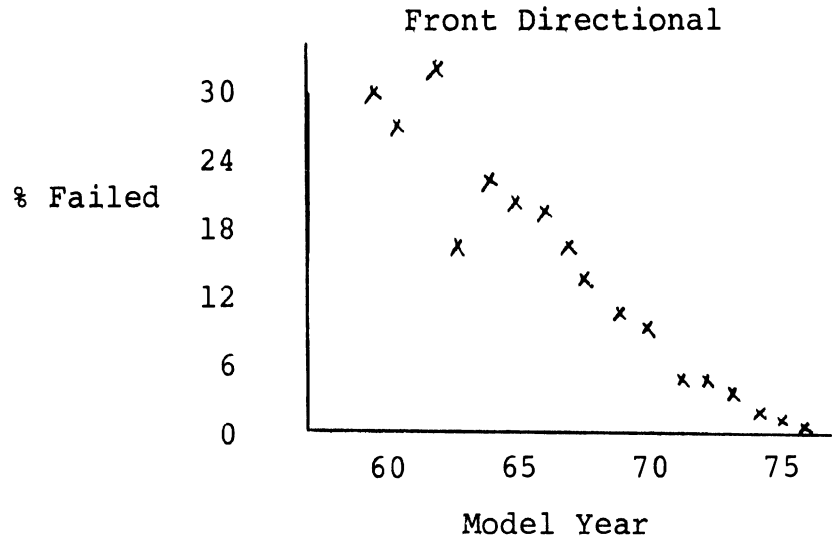
	Year	Total	Failed	% Failing
pre	1960	20	9	45.0
	1960	14	8	57.1
	1961	15	6	40.0
	1962	26	14	53.8
	1963	49	18	36.7
	1964	100	55	55.0
	1965	223	96	43.0
	1966	297	120	40.4
	1967	445	175	39.3
	1968	633	210	33.2
	1969	780	197	25.3
	1970	763	147	19.3
	1971	799	160	20.0
	1972	1029	153	14.9
	1973	1178	112	9.5
	1974	1025	87	8.5
	1975	783	44	5.6
	1976	726	8	1.1
	Total	8905	1619	18.2

Figure C-2



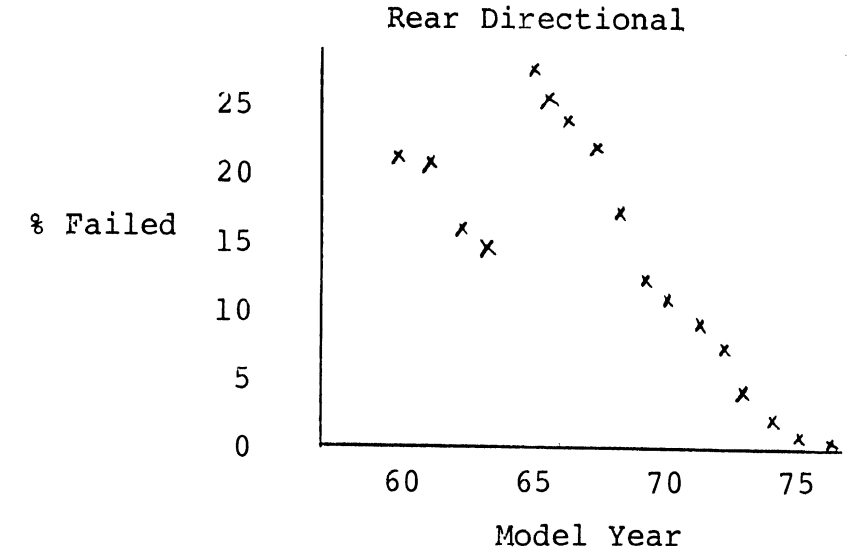
	Year	Total	Failed	% Failing
pre	1960	20	12	60.0
	1960	14	10	71.4
	1961	15	9	60.0
	1962	26	16	61.5
	1963	49	19	38.8
	1964	100	56	56.0
	1965	223	114	51.1
	1966	297	134	45.1
	1967	445	196	44.0
	1968	633	244	38.5
	1969	780	234	30.0
	1970	763	197	25.8
	1971	799	192	24.0
	1972	1029	183	17.8
	1973	1178	130	11.0
	1974	1025	92	9.0
	1975	783	47	6.0
	1976	726	8	1.1
	Total	8905	1893	21.3

Figure C-3



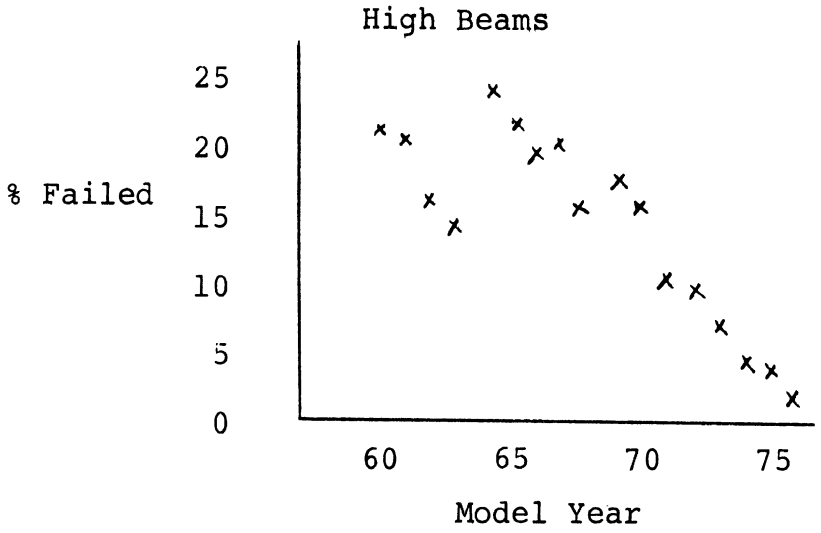
	Year	Total	Failed	% Failing
pre	1960	20	3	15.0
	1960	14	4	28.6
	1961	15	4	26.7
	1962	26	8	30.8
	1963	49	8	16.3
	1964	100	21	21.0
	1965	223	43	19.3
	1966	297	54	18.2
	1967	445	67	15.1
	1968	633	77	12.2
	1969	780	70	9.0
	1970	763	57	7.5
	1971	799	35	4.4
	1972	1029	44	4.3
	1973	1178	36	3.1
	1974	1025	17	1.7
	1975	783	6	0.8
	1976	726	2	0.3
	Total	8905	556	6.2

Figure C-4



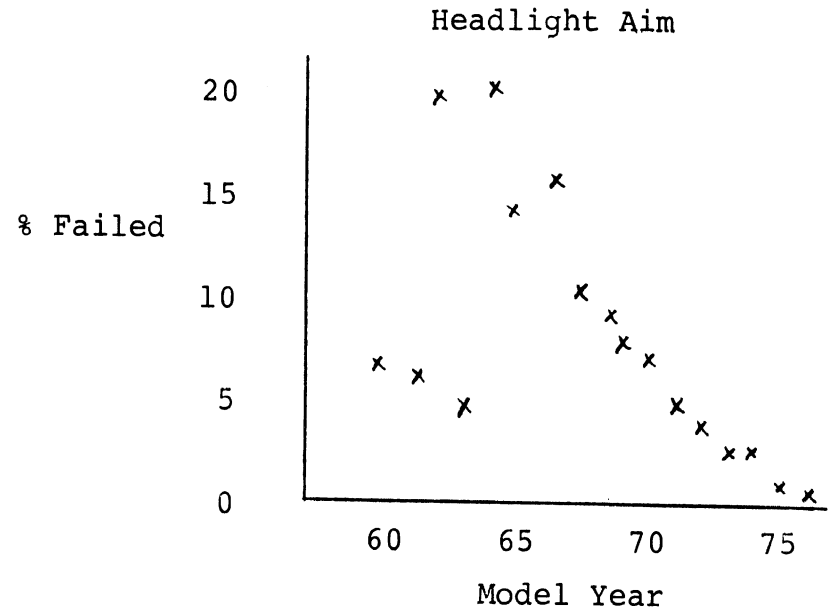
	Year	Total	Failed	% Failing
pre	1960	20	4	20.0
	1960	14	3	21.4
	1961	15	3	20.0
	1962	26	4	15.4
	1963	49	7	14.3
	1964	100	26	26.0
	1965	223	55	24.7
	1966	297	69	23.2
	1967	445	92	20.7
	1968	633	98	15.5
	1969	780	91	11.7
	1970	763	69	9.0
	1971	799	66	8.3
	1972	1029	58	5.6
	1973	1178	39	3.3
	1974	1025	22	2.1
	1975	783	7	0.9
	1976	726	4	0.6
	Total	8905	717	8.1

Figure C-5



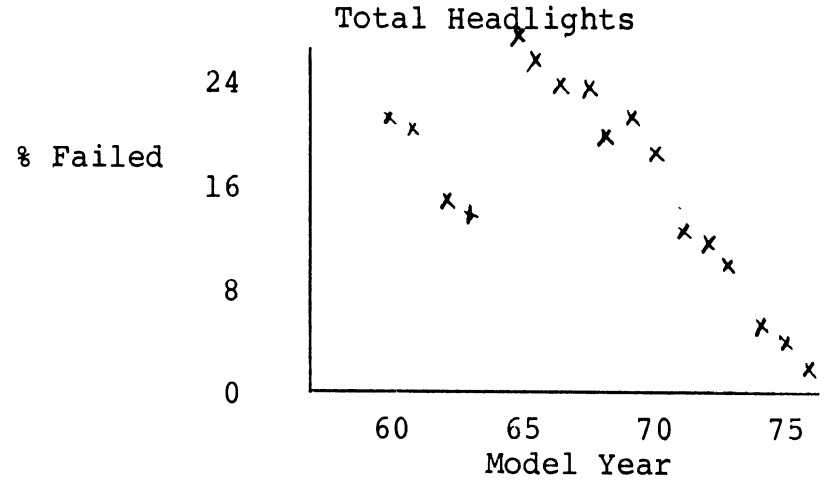
Year	Total	Failed	% Failing
pre 1960	20	4	20.0
1960	14	3	21.4
1961	15	3	20.0
1962	26	4	15.4
1963	49	7	14.3
1964	100	23	23.0
1965	223	48	21.5
1966	297	55	18.5
1967	445	86	19.3
1968	633	91	14.4
1969	780	137	17.6
1970	763	108	14.2
1971	799	75	9.4
1972	1029	86	8.4
1973	1178	78	6.6
1974	1025	37	3.6
1975	783	27	3.4
1976	726	15	2.1
Total	8905	887	10.0

Figure C-6



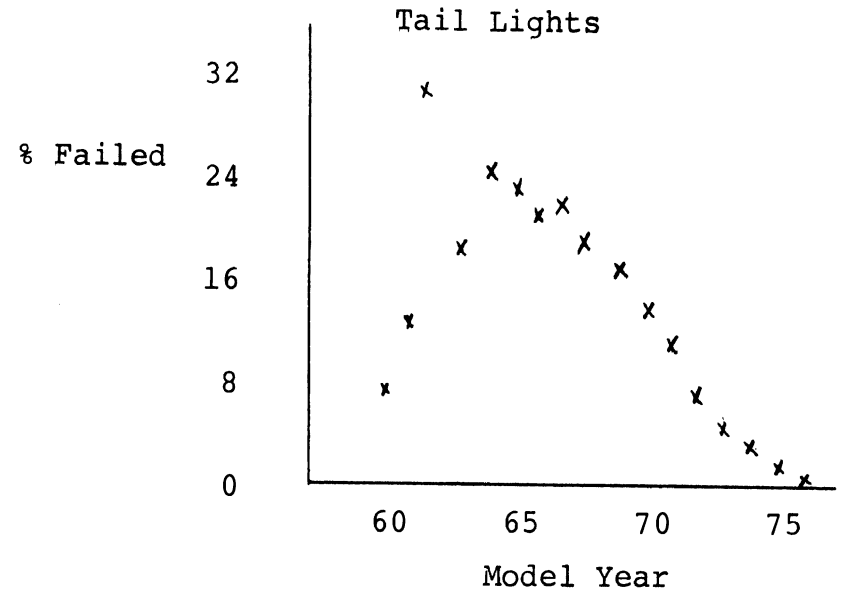
	Year	Total	Failed	% Failing
pre	1960	20	2	10.0
	1960	14	1	7.1
	1961	15	1	6.7
	1962	26	5	19.2
	1963	49	2	4.1
	1964	100	20	20.0
	1965	223	31	13.9
	1966	297	45	15.2
	1967	445	45	10.1
	1968	633	59	9.3
	1969	780	58	7.4
	1970	763	54	7.1
	1971	799	34	4.3
	1972	1029	35	3.4
	1973	1178	25	2.1
	1974	1025	22	2.1
	1975	783	5	0.6
	1976	726	2	0.3
	Total	8905	446	5.0

Figure C-7



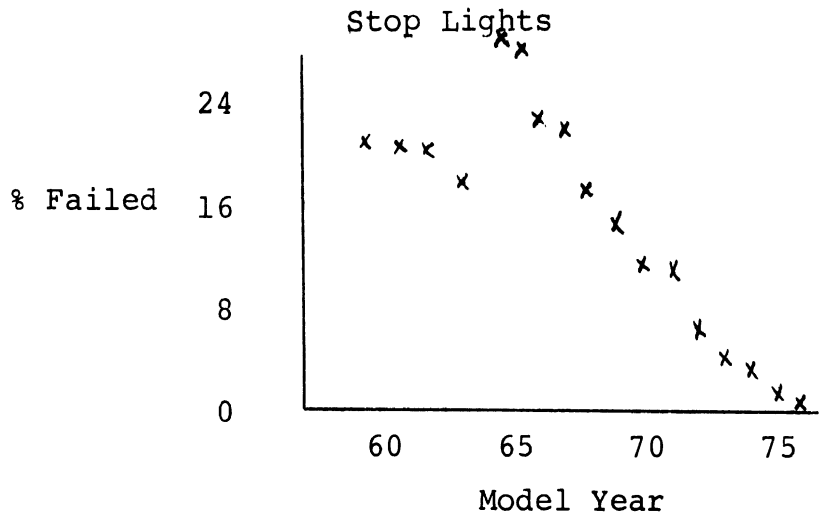
	Year	Total	Failed	% Failing
pre	1960	20	6	30.0
	1960	14	3	21.4
	1961	15	3	20.0
	1962	26	4	15.4
	1963	49	7	14.3
	1964	100	27	27.0
	1965	223	54	24.2
	1966	297	68	22.9
	1967	445	101	22.7
	1968	633	110	17.4
	1969	780	162	20.8
	1970	763	127	16.6
	1971	799	86	10.8
	1972	1029	106	10.3
	1973	1178	99	8.4
	1974	1025	45	4.4
	1975	783	29	3.7
	1976	726	16	2.2
	Total	8905	1053	11.8

Figure C-8



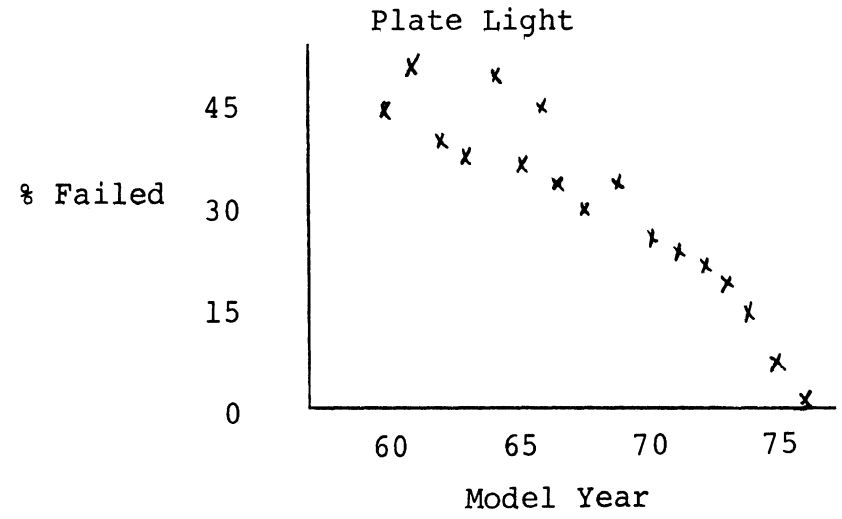
Year	Total	Failed	% Failing
pre 1960	20	5	25.0
1960	14	1	7.1
1961	15	2	13.3
1962	26	8	30.8
1963	49	9	18.4
1964	100	24	24.0
1965	223	52	23.3
1966	297	64	21.5
1967	445	101	22.7
1968	633	106	16.7
1969	780	117	15.0
1970	763	77	10.1
1971	799	72	9.0
1972	1029	71	6.9
1973	1178	56	4.8
1974	1025	37	3.6
1975	783	18	2.3
1976	726	6	0.8
Total	8905	826	9.3

Figure C-9



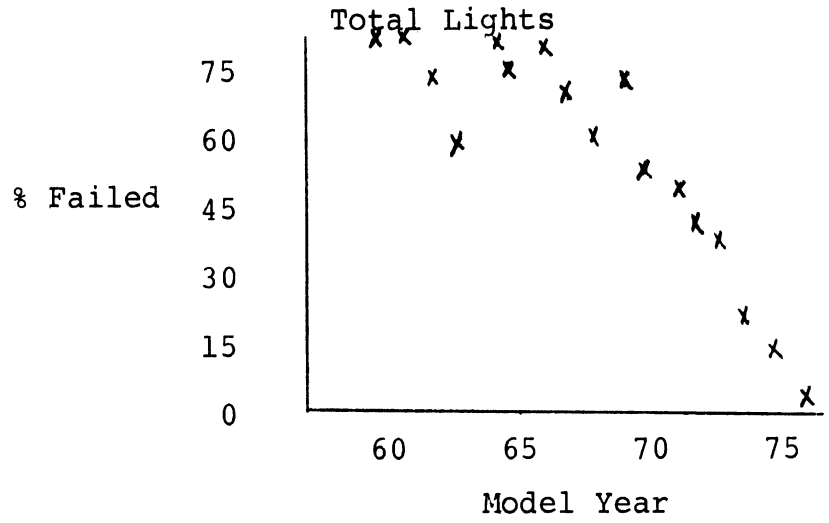
	Year	Total	Failed	% Failing
pre	1960	20	5	25.0
	1960	14	3	21.4
	1961	15	3	20.0
	1962	26	5	19.2
	1963	49	8	16.3
	1964	100	28	28.0
	1965	223	58	26.0
	1966	297	67	22.6
	1967	445	92	20.7
	1968	633	101	16.0
	1969	780	104	13.3
	1970	763	77	10.1
	1971	799	80	10.0
	1972	1029	58	5.6
	1973	1178	45	3.8
	1974	1025	31	3.0
	1975	783	10	1.3
	1976	726	3	0.4
	Total	8905	778	8.7

Figure C-10



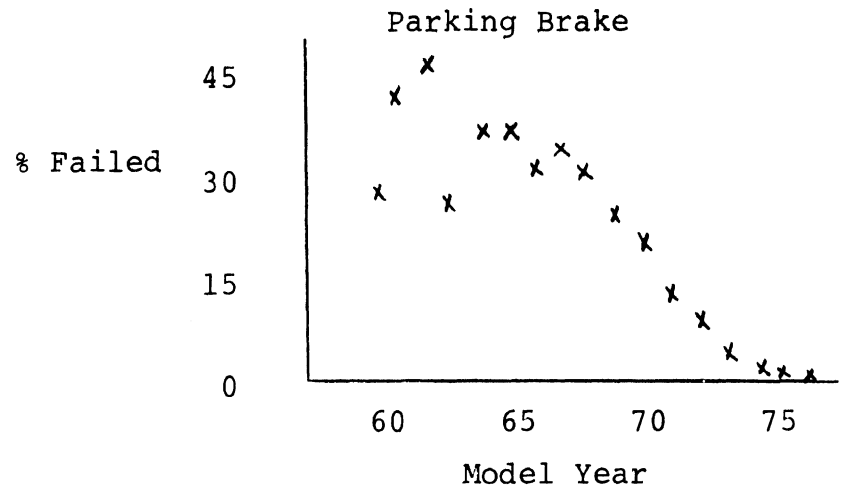
	Year	Total	Failed	% Failing
pre	1960	20	8	40.0
	1960	14	6	42.9
	1961	15	8	53.3
	1962	26	10	38.5
	1963	49	18	36.7
	1964	100	48	48.0
	1965	223	77	34.5
	1966	297	126	42.4
	1967	445	139	31.2
	1968	633	186	29.4
	1969	780	248	31.8
	1970	763	185	24.2
	1971	799	189	23.7
	1972	1029	219	21.3
	1973	1178	198	16.8
	1974	1025	115	11.2
	1975	783	42	5.4
	1976	726	9	1.2
	Total	8905	1831	20.6

Figure C-11



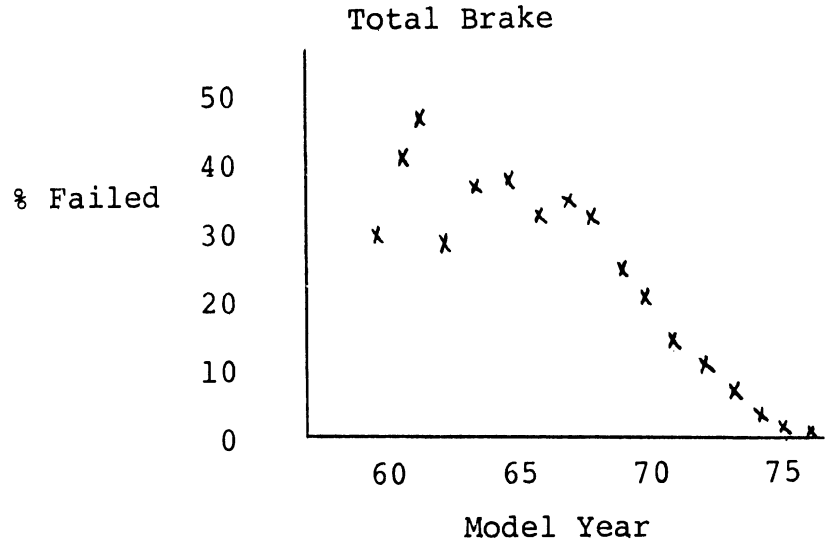
	Year	Total	Failed	% Failing
pre	1960	20	12	60.0
	1960	14	11	78.6
	1961	15	12	80.0
	1962	26	18	69.2
	1963	49	29	59.2
	1964	100	77	77.0
	1965	223	157	70.4
	1966	297	223	75.1
	1967	445	282	63.4
	1968	633	364	57.5
	1969	780	480	61.5
	1970	763	396	51.9
	1971	799	370	46.3
	1972	1029	398	38.7
	1973	1178	365	31.0
	1974	1025	208	20.3
	1975	783	95	12.1
	1976	726	38	5.2
	Total	8905	3535	39.7

Figure C-12



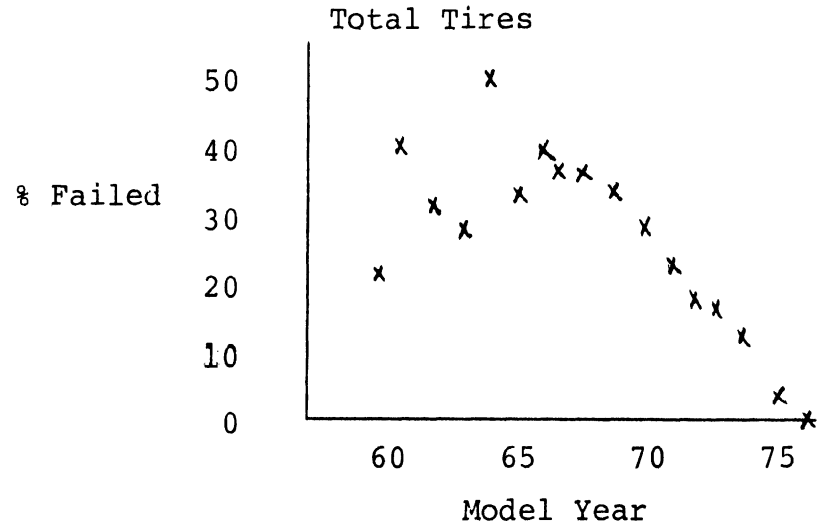
	Year	Total	Failed	% Failing
pre	1960	20	5	25.0
	1960	14	4	28.6
	1961	15	6	40.0
	1962	26	12	46.2
	1963	49	12	24.5
	1964	100	36	36.0
	1965	223	80	35.9
	1966	297	89	30.0
	1967	445	145	32.6
	1968	633	186	29.4
	1969	780	174	22.3
	1970	763	138	18.1
	1971	799	94	11.8
	1972	1029	94	9.1
	1973	1178	57	4.8
	1974	1025	28	2.7
	1975	783	13	1.7
	1976	726	1	0.1
	Total	8905	1174	13.2

Figure C-13



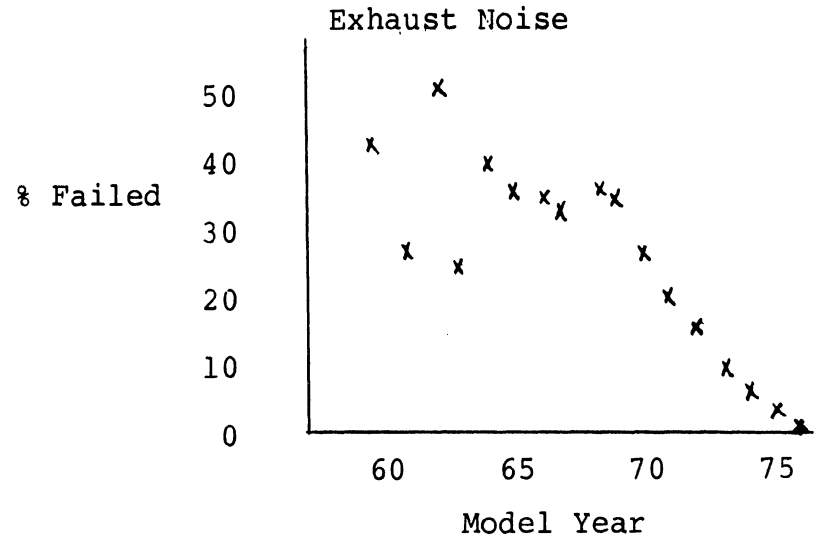
	Year	Total	Failed	% Failing
pre	1960	20	7	35.0
	1960	14	4	28.6
	1961	15	6	40.0
	1962	26	12	46.2
	1963	49	14	28.6
	1964	100	36	36.0
	1965	223	84	37.7
	1966	297	92	31.0
	1967	445	150	33.7
	1968	633	191	30.2
	1969	780	182	23.3
	1970	763	139	18.2
	1971	799	96	12.0
	1972	1029	95	9.2
	1973	1178	61	5.2
	1974	1025	29	2.8
	1975	783	13	1.7
	1976	726	1	0.1
	Total	8905	1212	13.6

Figure C-14



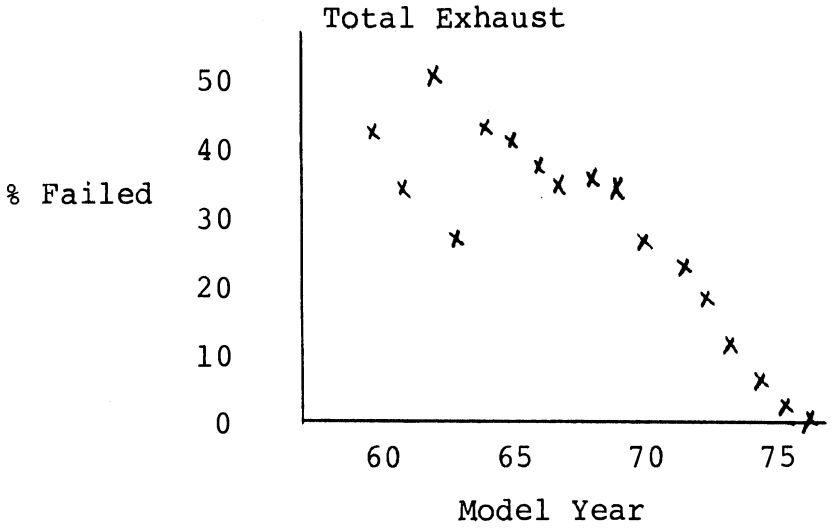
	Year	Total	Failed	% Failing
pre	1960	20	9	45.0
	1960	14	3	21.4
	1961	15	6	40.0
	1962	26	8	30.8
	1963	49	14	28.6
	1964	100	49	49.0
	1965	223	72	32.3
	1966	297	115	38.7
	1967	445	157	35.3
	1968	633	221	34.9
	1969	780	242	31.0
	1970	763	209	27.4
	1971	799	161	20.2
	1972	1029	170	16.5
	1973	1178	167	14.2
	1974	1025	124	12.1
	1975	783	24	3.1
	1976	726	0	0.0
	Total	8905	1751	19.7

Figure C-15



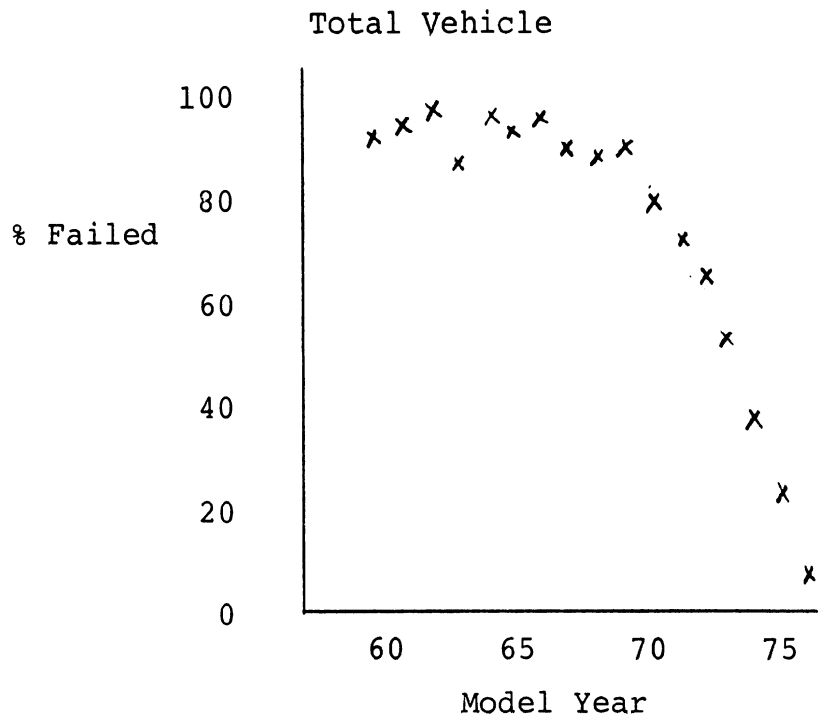
	Year	Total	Failed	% Failing
pre	1960	20	7	35.0
	1960	14	6	42.9
	1961	15	4	26.7
	1962	26	13	50.0
	1963	49	11	22.4
	1964	100	39	39.0
	1965	223	76	34.1
	1966	297	101	34.0
	1967	445	137	30.8
	1968	633	220	34.8
	1969	780	267	34.2
	1970	763	178	23.3
	1971	799	151	18.9
	1972	1029	160	15.5
	1973	1178	117	9.9
	1974	1025	50	4.9
	1975	783	18	2.3
	1976	726	2	0.3
	Total	8905	1557	17.5

Figure C-16



	Year	Total	Failed	% Failing
pre	1960	20	7	35.0
	1960	14	6	42.9
	1961	15	5	33.3
	1962	26	13	50.0
	1963	49	12	24.5
	1964	100	42	42.0
	1965	223	88	39.5
	1966	297	110	37.0
	1967	445	153	34.4
	1968	633	233	36.8
	1969	780	272	34.9
	1970	763	183	24.0
	1971	799	164	20.5
	1972	1029	163	15.8
	1973	1178	124	10.5
	1974	1025	51	5.0
	1975	783	18	2.3
	1976	726	2	0.3
	Total	8905	1646	18.5

Figure C-17



	Year	Total	Failed	% Failing
pre	1960	20	17	85.0
	1960	14	13	92.9
	1961	15	14	93.3
	1962	26	25	96.2
	1963	49	41	83.7
	1964	100	95	95.0
	1965	223	204	91.5
	1966	297	276	92.9
	1967	445	385	86.5
	1968	633	541	85.5
	1969	780	671	86.0
	1970	763	593	77.7
	1971	799	544	68.1
	1972	1029	638	62.0
	1973	1178	586	49.7
	1974	1025	388	37.9
	1975	783	165	21.1
	1976	726	55	7.6
	Total	8905	5251	59.0

Figure C-18

APPENDIX D

DETAILED COMPARISON TABLES

Table D-1

Total Vehicle
Percent Failure Rates

Vehicle Age	Reinspected Vehicles Jackson County 1975	Reinspected Vehicles Jackson County 1976	Newly Inspected Vehicles Jackson County 1975	Newly Inspected Vehicles Jackson County 1976	Newly Inspected Vehicles Monroe County 1975	Newly Inspected Vehicles Monroe County 1976
1	9.3	0.0	11.3	7.5	8.7	7.9
2	22.0	15.7	25.0	21.3	24.8	19.5
3	29.7	32.7	37.0	35.9	40.1	44.1
4	42.0	36.8	48.0	47.8	50.4	54.5
5	49.2	51.7	58.1	58.8	59.5	69.7
6	53.4	52.4	62.4	65.7	66.7	77.0
7	64.5	64.2	71.7	76.1	79.2	82.5
8	60.4	63.9	78.9	85.4	85.1	86.9
9	78.7	69.8	84.0	85.1	85.9	85.4
10	75.0	76.0	89.1	86.5	84.0	87.1
11	78.8	81.8	89.3	93.8	94.6	91.7
12	77.8	72.7	88.9	91.0	80.0	89.8
13	71.4	88.9	89.2	93.4	85.7	100.0
14	100.0	57.1	87.5	83.9	100.0	88.2
15	100.0	100.0	100.0	91.7	100.0	100.0
16	100.0	100.0	100.0	91.7	100.0	100.0
17+	100.0	66.7	72.2	80.8	100.0	100.0
Overall	38.5	45.2	49.6	57.9	51.9	62.0

Table D-2

Wipers and Washers
Percent Failure Rates

Vehicle Age	Reinspected Vehicles Jackson County 1975	Reinspected Vehicles Jackson County 1976	Newly Inspected Vehicles Jackson County 1975	Newly Inspected Vehicles Jackson County 1976	Newly Inspected Vehicles Monroe County 1975	Newly Inspected Vehicles Monroe County 1976
1	3.0	0.0	4.1	0.7	3.3	2.6
2	6.2	3.3	7.2	4.4	9.5	10.2
3	9.6	7.6	10.1	8.2	14.0	11.4
4	10.9	7.1	14.2	9.5	18.5	14.9
5	13.4	14.3	17.0	15.3	20.8	23.2
6	16.5	17.1	20.2	21.9	18.9	30.5
7	22.9	17.6	26.4	23.6	31.2	33.9
8	18.9	17.5	30.9	30.1	39.6	29.1
9	34.7	20.8	35.9	36.8	47.4	43.8
10	27.3	18.7	40.6	44.7	50.0	41.9
11	39.4	15.9	43.7	42.5	59.5	52.8
12	38.9	21.2	50.4	53.0	50.0	44.1
13	28.6	22.2	54.1	56.6	57.1	52.0
14	33.3	28.6	53.1	41.9	50.0	35.3
15	100.0	33.3	80.0	58.3	50.0	66.7
16	66.7	100.0	62.5	66.7	100.0	33.3
17+	33.3	50.0	38.9	69.2	60.0	50.0
Overall	12.4	11.8	17.6	20.1	21.4	24.2

Table D-3

Headlights
Percent Failure Rates

Vehicle Age	Reinspected Vehicles Jackson County 1975	Reinspected Vehicles Jackson County 1976	Newly Inspected Vehicles Jackson County 1975	Newly Inspected Vehicles Jackson County 1976	Newly Inspected Vehicles Monroe County 1975	Newly Inspected Vehicles Monroe County 1976
1	1.5	0.0	1.7	2.6	1.3	0.7
2	3.6	3.9	3.6	3.7	1.9	2.9
3	5.1	5.2	5.3	4.6	3.4	4.0
4	7.4	5.6	7.7	8.8	6.0	6.9
5	9.8	9.7	9.1	11.1	4.8	7.7
6	9.1	9.3	10.1	9.9	10.1	13.8
7	10.2	14.8	16.1	15.6	12.3	20.2
8	11.3	10.8	17.3	20.1	10.9	22.3
9	13.3	12.3	19.5	17.0	19.2	18.2
10	13.6	17.3	21.9	21.9	20.0	25.8
11	6.1	15.9	16.7	23.9	27.0	22.2
12	22.2	12.1	18.8	25.3	20.0	20.3
13	14.3	16.7	18.9	25.0	21.4	32.0
14	66.7	28.6	28.1	12.9	12.5	17.6
15	0.0	0.0	20.0	16.7	0.0	0.0
16	33.3	0.0	37.5	25.0	0.0	0.0
17+	33.3	33.3	22.2	30.8	20.0	12.5
Overall	6.8	8.4	9.2	11.8	7.3	11.6

Table D-4

Total Lights
Percent Failure Rates

Vehicle Age	Reinspected Vehicles Jackson County 1975	Reinspected Vehicles Jackson County 1976	Newly Inspected Vehicles Jackson County 1975	Newly Inspected Vehicles Jackson County 1976	Newly Inspected Vehicles Monroe County 1975	Newly Inspected Vehicles Monroe County 1976
1	5.1	0.0	5.8	5.4	4.7	4.6
2	13.5	10.5	13.2	12.9	12.4	9.8
3	19.0	19.4	22.2	20.7	23.6	19.9
4	28.3	23.2	30.2	31.2	27.6	29.2
5	32.1	31.1	37.3	38.8	34.5	37.3
6	34.1	30.9	41.2	45.3	38.4	50.6
7	41.6	40.3	48.1	50.2	43.5	57.4
8	42.5	38.0	56.0	62.5	58.4	57.1
9	60.0	45.3	61.7	59.4	56.4	50.4
10	59.1	48.0	67.8	63.5	56.0	63.4
11	48.5	61.4	65.1	77.4	73.0	69.4
12	61.1	54.5	65.8	70.5	60.0	67.8
13	71.4	66.7	64.9	76.3	57.1	80.0
14	66.7	42.9	75.0	51.6	75.0	76.5
15	100.0	33.3	70.0	62.5	100.0	100.0
16	33.3	100.0	50.0	83.3	100.0	100.0
17+	33.3	66.7	55.6	65.4	80.0	75.0
Overall	25.3	28.3	32.6	40.0	31.1	38.4

Table D-5

Total Brakes
Percent Failure Rates

Vehicle Age	Reinspected Vehicles Jackson County 1975	Reinspected Vehicles Jackson County 1976	Newly Inspected Vehicles Jackson County 1975	Newly Inspected Vehicles Jackson County 1976	Newly Inspected Vehicles Monroe County 1975	Newly Inspected Vehicles Monroe County 1976
1	1.2	0.0	0.8	0.0	1.3	0.7
2	1.2	0.6	1.0	1.7	1.3	1.5
3	1.8	2.8	2.9	2.0	5.8	5.1
4	4.6	2.5	4.8	5.3	5.6	4.9
5	6.5	4.3	10.2	8.1	12.5	12.2
6	9.7	6.9	14.1	11.0	19.5	16.7
7	9.6	14.8	18.9	16.3	22.7	23.0
8	8.5	10.2	22.7	21.9	26.7	26.9
9	24.0	13.2	29.8	29.5	28.2	31.4
10	6.8	21.3	28.8	32.9	40.0	38.7
11	27.3	11.4	32.1	29.6	29.7	34.7
12	11.1	24.2	39.3	35.5	45.0	42.4
13	14.3	16.7	27.0	34.2	35.7	40.0
14	33.3	0.0	37.5	29.0	62.5	29.4
15	0.0	33.3	20.0	50.0	0.0	0.0
16	0.0	0.0	25.0	50.0	100.0	0.0
17+	33.3	0.0	38.9	30.7	60.0	37.5
Overall	5.2	6.0	10.2	12.9	12.7	15.4

Table D-6

Total Tires
Percent Failure Rates

Vehicle Age	Reinspected Vehicles Jackson County 1975	Reinspected Vehicles Jackson County 1976	Newly Inspected Vehicles Jackson County 1975	Newly Inspected Vehicles Jackson County 1976	Newly Inspected Vehicles Monroe County 1975	Newly Inspected Vehicles Monroe County 1976
1	0.0	0.0	0.4	0.0	0.0	0.0
2	2.1	2.4	4.2	2.9	3.2	3.4
3	6.5	11.4	8.4	10.8	8.6	15.1
4	9.1	10.7	10.7	13.3	13.4	16.3
5	15.0	16.0	13.4	15.3	12.5	19.6
6	10.8	10.2	13.5	18.3	15.1	26.4
7	13.9	22.2	18.7	25.8	20.8	32.2
8	17.0	22.3	24.4	30.0	17.8	33.7
9	10.7	31.1	22.3	36.0	26.9	31.4
10	20.5	30.7	24.7	35.4	26.0	35.5
11	18.2	34.1	28.4	35.8	32.4	48.6
12	5.6	24.2	23.9	28.9	30.0	40.7
13	28.6	33.3	32.4	46.1	42.9	56.0
14	0.0	14.3	25.0	22.6	12.5	41.2
15	0.0	33.3	30.0	29.2	0.0	33.3
16	33.3	100.0	50.0	33.3	0.0	66.7
17+	33.3	40.0	27.8	34.6	0.0	37.5
Overall	8.0	14.4	12.0	18.8	12.3	22.2

Table D-7

Total Vehicle
Percentage Failure Rates

Vehicle Mileage (1,000's)	Reinspected Vehicles Jackson County 1975	Reinspected Vehicles Jackson County 1976	Newly Inspected Vehicles Jackson County 1975	Newly Inspected Vehicles Jackson County 1976	Newly Inspected Vehicles Monroe County 1975	Newly Inspected Vehicles Monroe County 1976
0-10	9.3	7.7	10.2	7.1	13.6	7.3
10-20	15.3	15.1	17.7	19.4	20.4	25.0
20-30	29.8	27.4	32.1	36.0	38.4	47.6
30-40	34.5	35.1	41.5	43.1	46.6	54.5
40-50	44.1	35.6	50.0	53.3	52.9	62.8
50-60	47.6	47.2	59.2	64.1	63.1	71.5
60-70	56.7	56.2	63.9	70.1	71.4	71.9
70-80	59.9	66.1	74.4	77.9	75.5	82.2
80-90	72.8	71.5	77.2	82.0	87.4	88.9
90-100	77.8	70.8	82.6	85.2	83.9	89.7
100+	75.9	80.8	85.3	88.3	89.3	92.5
Overall	38.5	45.2	49.5	57.9	51.9	62.0

Table D-8

Wipers and Washers
Percentage Failure Rates

Vehicle Mileage (1,000's)	Reinspected Vehicles Jackson County 1975	Reinspected Vehicles Jackson County 1976	Newly Inspected Vehicles Jackson County 1975	Newly Inspected Vehicles Jackson County 1976	Newly Inspected Vehicles Monroe County 1975	Newly Inspected Vehicles Monroe County 1976
0-10	2.6	0.0	3.5	0.6	5.3	2.2
10-20	3.5	2.9	5.0	4.2	9.8	11.9
20-30	9.7	5.6	9.4	7.7	12.1	18.8
30-40	8.6	8.1	13.0	11.3	20.2	11.1
40-50	13.1	10.2	15.7	15.7	16.6	25.7
50-60	12.7	12.7	20.4	19.5	27.9	24.8
60-70	23.3	12.7	24.7	23.9	33.3	28.1
70-80	23.9	19.5	26.4	30.0	35.3	31.7
80-90	23.7	21.5	29.7	34.5	35.1	37.4
90-100	31.5	18.9	31.9	36.3	42.9	44.8
100+	26.5	23.1	36.5	37.4	33.3	44.3
Overall	12.4	11.8	17.5	20.1	21.4	24.2

Table D-9

Headlights
Percentage Failure Rates

Vehicle Mileage (1,000's)	Reinspected Vehicles Jackson County		Newly Inspected Vehicles Jackson County		Newly Inspected Vehicles Monroe County	
	1975	1976	1975	1976	1975	1976
0-10	1.3	5.1	1.7	2.4	1.2	0.6
10-20	3.1	3.4	2.2	2.7	1.8	3.4
20-30	3.1	4.7	3.7	5.9	4.0	2.1
30-40	5.8	4.9	5.4	7.1	4.8	7.1
40-50	7.8	7.8	9.1	11.0	7.2	10.7
50-60	11.1	8.8	10.3	10.3	8.9	14.0
60-70	8.4	10.1	12.2	15.0	7.1	13.8
70-80	10.6	11.4	15.1	15.0	14.4	20.8
80-90	14.0	11.8	16.6	19.5	18.9	20.5
90-100	9.3	14.2	21.1	16.8	14.3	17.2
100+	19.3	17.3	19.3	23.0	14.3	21.3
Overall	6.8	8.4	9.2	11.8	7.3	11.6

Table D-10

Total Lights
Percentage Failure Rates

Vehicle Mileage (1,000's)	Reinspected Vehicles Jackson County 1975	Reinspected Vehicles Jackson County 1976	Newly Inspected Vehicles Jackson County 1975	Newly Inspected Vehicles Jackson County 1976	Newly Inspected Vehicles Monroe County 1975	Newly Inspected Vehicles Monroe County 1976
0-10	5.4	7.7	5.2	4.9	7.1	4.5
10-20	10.1	9.7	10.0	12.3	8.9	9.1
20-30	16.5	15.9	16.4	20.3	21.0	22.0
30-40	21.5	20.8	25.2	26.2	25.0	32.8
40-50	32.0	22.2	32.7	35.9	34.5	32.0
50-60	33.3	28.9	38.5	40.9	35.2	41.7
60-70	33.0	32.2	41.2	50.3	36.9	44.3
70-80	45.1	42.8	53.6	54.1	48.9	59.4
80-90	46.5	46.5	56.0	58.0	62.2	59.1
90-100	55.6	48.1	60.6	64.2	64.3	66.7
100+	54.2	54.5	60.3	68.2	59.5	67.8
Overall	25.3	28.3	32.5	40.0	31.1	38.4

Table D-11

Total Brakes
Percentage Failure Rates

Vehicle Mileage (1,000's)	Reinspected Vehicles Jackson County 1975	Reinspected Vehicles Jackson County 1976	Newly Inspected Vehicles Jackson County 1975	Newly Inspected Vehicles Jackson County 1976	Newly Inspected Vehicles Monroe County 1975	Newly Inspected Vehicles Monroe County 1976
0-10	1.3	2.6	0.9	0.4	2.4	0.6
10-20	1.4	0.4	1.1	1.3	2.2	4.0
20-30	2.3	2.2	2.9	3.0	7.1	6.8
30-40	3.7	5.2	5.1	5.0	8.2	5.5
40-50	5.9	3.6	7.5	6.9	10.8	11.1
50-60	6.7	5.3	10.7	14.3	10.1	16.1
60-70	7.9	5.1	13.8	14.5	16.1	15.2
70-80	12.0	6.8	20.0	18.5	20.9	23.3
80-90	8.8	11.1	19.0	25.3	30.6	30.4
90-100	16.7	15.1	26.1	25.3	30.4	25.3
100+	12.0	21.2	29.6	28.7	41.7	43.1
Overall	5.2	6.0	10.2	12.9	12.7	15.4

Table D-12

Total Tires
Percentage Failure Rates

Vehicle Mileage (1,000's)	Reinspected Vehicles Jackson County 1975	Reinspected Vehicles Jackson County 1976	Newly Inspected Vehicles Jackson County 1975	Newly Inspected Vehicles Jackson County 1976	Newly Inspected Vehicles Monroe County 1975	Newly Inspected Vehicles Monroe County 1976
0-10	0.3	0.0	0.2	0.0	0.0	0.0
10-20	1.0	2.9	2.4	2.3	1.8	3.4
20-30	6.0	8.4	6.5	9.1	7.1	19.4
30-40	6.5	6.8	8.2	12.2	8.7	17.0
40-50	8.5	10.2	11.7	14.1	12.1	17.4
50-60	9.5	14.8	13.2	18.4	16.8	21.9
60-70	13.5	19.9	14.5	23.8	19.0	23.8
70-80	10.6	19.1	19.1	28.1	24.5	35.6
80-90	21.1	27.1	20.7	29.5	20.7	35.1
90-100	25.9	29.2	27.9	30.2	25.0	39.1
100+	20.5	32.1	28.4	36.2	26.2	43.1
Overall	8.0	14.4	12.0	18.8	12.3	22.2

Table D-13

Total Vehicle Counts

Vehicle Age	Reinspected Vehicles				Newly Inspected Vehicles							
	Jackson County				Jackson County				Monroe County			
	1975		1976		1975		1976		1975		1976	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
1	339	13.5	14	.6	1060	10.8	574	8.5	150	8.4	152	7.1
2	427	17.0	339	13.5	1450	14.7	578	8.5	315	17.6	205	9.6
3	467	18.6	427	17.0	1598	16.3	753	11.1	292	16.3	272	12.7
4	345	13.8	467	18.5	1388	14.1	890	13.2	232	13.0	288	13.5
5	264	10.5	345	13.7	930	9.5	758	11.2	168	9.4	271	12.7
6	190	7.6	264	10.5	772	7.9	625	9.2	159	8.9	174	8.1
7	165	6.6	190	7.5	815	8.3	580	8.6	154	8.6	183	8.6
8	118	4.7	165	6.6	611	6.2	605	8.9	101	5.7	175	8.2
9	78	3.1	118	4.7	457	4.6	496	7.3	78	4.4	137	6.4
10	42	1.7	78	3.1	320	3.3	352	5.2	50	2.8	93	4.4
11	35	1.4	42	1.7	215	2.2	225	3.3	37	2.1	72	3.4
12	18	0.7	35	1.4	117	1.2	164	2.4	20	1.1	59	2.8
13	6	0.2	18	0.7	37	0.4	75	1.1	14	0.8	25	1.2
14	4	0.2	6	0.2	32	0.3	32	0.5	8	0.4	17	0.8
15	1	0.1	4	0.2	10	0.1	23	0.3	2	0.1	3	0.1
16	3	0.1	1	0.1	8	0.1	12	0.2	1	0.1	3	0.1
17+	3	0.1	6	0.2	13	0.1	26	0.3	5	0.3	8	0.4
	2505		2519		9860		6768		1786		2137	

Table D-14

1975 Brake Data - Failure Percentages for
Vehicles Which had Wheel Pulled in the Wheel-Pull Test

Age (Years)	Count	Stationary Test			Moving-Stopping Test									Stopping Defects			Wheel-Pull Test				
					Pedal Pressure Test					Stopping Test										Rotor or Drum	
		Foot Brake	Parking Brake	Total Brake	Pedal Soft	Low Pedal	Pressure Loss	Hard Pedal	Pulsating Pedal	Cannot Stop	Side-to-Side	Both	Stopping Audible	1	2	3	Master Cyl Reservoir Level Low	Shoe-Pad Condition <1/32"	Cracked	Worn	Grooves
0-1	123	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	1.6	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	271	0.0	0.7	0.7	0.7	0.4	0.0	0.7	0.0	0.0	5.2	0.0	4.4	9.6	0.4	0.4	1.8	0.7	0.4	1.1	1.9
3	352	0.9	3.7	4.3	0.9	0.9	0.0	0.6	0.6	0.3	4.5	0.0	5.4	9.4	1.4	0.3	1.1	1.1	0.3	2.3	3.1
4	299	0.7	6.4	7.0	1.3	1.7	0.0	1.3	2.0	0.0	9.4	0.0	10.4	19.4	2.3	0.7	3.0	1.7	0.0	1.0	3.4
5	200	2.5	10.0	11.0	0.0	3.0	1.5	0.5	1.0	3.5	8.0	0.0	6.5	13.5	3.0	1.5	5.1	3.0	0.0	1.5	4.5
6	189	2.1	15.9	17.5	1.6	3.7	0.5	0.0	1.6	2.6	13.8	0.0	9.5	23.3	4.2	0.5	4.3	7.0	0.5	3.2	9.1
7	202	2.0	25.2	26.7	2.0	2.5	0.0	1.0	0.5	2.5	12.4	1.0	13.4	19.8	5.4	1.5	3.5	8.5	0.0	0.5	15.7
8	157	7.6	27.4	29.3	1.3	6.4	1.9	0.0	1.9	4.5	21.0	1.9	20.4	20.4	12.7	4.5	1.3	8.9	0.0	1.3	18.2
9	111	3.6	31.5	32.4	4.5	7.3	0.9	0.9	0.0	1.8	13.6	4.5	15.5	22.7	6.4	4.5	5.6	4.5	0.0	0.9	13.6
10	79	2.5	34.2	35.4	1.3	6.3	0.0	3.8	1.3	1.3	24.1	0.0	19.0	40.5	6.3	1.3	10.3	6.5	0.0	0.0	11.4
11+	120	4.2	38.3	39.2	0.8	7.5	0.0	1.7	0.8	3.3	25.0	1.7	16.7	31.7	9.2	2.5	15.1	10.8	0.0	0.0	27.5
Total	2103	1.9	13.6	14.4	1.2	2.8	0.4	0.8	0.9	1.5	10.7	0.6	9.8	17.1	3.9	1.3	3.8	4.0	0.1	1.3	7.7

Table D-15

1975 Brake Data - Failure Percentages for Vehicles Which had Wheel Pulled in Wheel-Pull Test

Mileage (1,000's)	Count	Stationary Test			Moving-Stopping Test									Stopping Defects			Wheel-Pull Test				
					Pedal Pressure Test					Stopping Test									Rotor or Drum		
		Foot Brake	Parking Brake	Total Brake	Pedal Soft	Low Pedal	Pressure Loss	Hard Pedal	Pulsating Pedal	Cannot Stop	Side-to-Side	Both	Stopping Audible	1	2	3	Master Cylinder Res.Low	Shoe-Pad Condition <1/32"	Cracked	Worn	Grooves
0-10	105	0.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	3.8	0.0	1.0	3.8	0.0	1.0	1.0	0.0	0.0	0.0	1.0
10-20	178	0.0	1.7	1.7	0.6	0.0	0.0	0.0	0.6	0.0	5.1	0.0	6.7	10.7	1.1	0.0	1.1	1.1	0.0	0.6	1.7
20-30	248	0.0	2.4	2.4	0.4	0.0	0.0	0.8	0.8	0.0	4.8	0.0	3.2	8.1	0.4	0.4	3.3	0.8	0.0	2.0	2.8
30-40	257	1.2	8.2	8.9	1.2	0.8	0.0	0.4	1.6	0.4	6.6	0.0	6.6	14.4	1.6	0.0	1.6	2.4	0.4	1.6	4.0
40-50	263	2.3	9.9	11.4	1.1	3.4	0.0	0.8	1.1	1.9	9.1	0.4	9.5	13.7	3.4	2.3	4.2	5.3	0.4	1.9	4.6
50-60	231	0.4	12.6	12.6	0.4	1.7	0.0	1.7	0.9	0.9	11.7	0.0	7.4	14.7	4.3	0.4	2.6	7.0	0.0	0.9	8.0
60-70	226	0.9	17.7	17.7	2.7	2.7	0.0	0.9	0.9	2.7	11.9	0.9	10.2	19.0	4.9	1.3	3.6	4.0	0.0	0.9	8.4
70-80	183	3.8	19.7	21.3	1.1	5.5	1.6	1.1	2.2	3.3	14.8	0.5	15.3	24.6	7.1	2.2	6.7	5.5	0.6	1.1	8.9
80-90	169	3.0	24.3	26.0	1.2	8.3	0.0	1.8	0.0	3.0	18.3	2.4	23.1	32.0	9.5	2.4	8.6	6.0	0.0	1.8	15.6
90-100	108	7.4	26.9	30.6	1.9	1.9	2.8	0.9	0.0	1.9	17.6	1.9	13.9	28.7	5.6	0.9	5.8	3.7	0.0	0.9	13.9
100+	135	6.7	40.7	42.2	2.3	8.3	1.5	0.0	0.8	3.8	21.1	1.5	15.8	27.8	6.8	4.5	4.8	8.2	0.0	1.5	25.2
Total	2103	1.9	13.6	14.5	1.2	2.8	0.4	0.8	0.9	1.5	10.7	0.6	9.8	17.1	3.9	1.3	3.8	4.0	0.1	1.3	7.7

APPENDIX E

BIBLIOGRAPHY

MOTOR VEHICLE INSPECTION BIBLIOGRAPHY

"Aids to Conduct and Publicize Your Vehicle Safety-Check Program", National Vehicle Safety Check for Communities, Washington, 1961. 06124

How to effectively use the media services.

Annarino, J.A., "One Year of Vehicle Inspection", Indianapolis Department of Traffic Safety, 1970. 15276-A05

The inception of Indiana's PMVI law, statistical summary of first year's operation, recommendations for future improvements.

American Association of Motor Vehicle Administrators 1968 Conference Presentation, 1968. HSRI-29046

Papers on technical aspects of air pollution, brakes, lighting, noise, steering, suspension, and tires as may be of interest to auto safety inspectors.

Barrett, R.F., "Cost Effectiveness Guidelines for Motor Vehicle Safety Inspection Programs", North Carolina State University, Raleigh, 1972. (27931)

Defect rates by component, cost of inspection by component, recommendation for improvements in inspection procedure.

Berry, J.R., "Periodic Motor Vehicle Inspection: A Comparative Data Analysis", American Association of Motor Vehicle Administrators, 1972. 19054

Contains administrative summary and charts as well as inspection standards summary and charts.

Bentz, L.J., "Motor Vehicle Inspection", Automobile Club of Southern California, 1970. 27916

Conclusions regarding the effectivenss of PMVI in reducing traffic accidents and fatalities, as well as its effect in reducing vehicle defect rates. Recommendations for reallocation of PMVI funds.

Brainerd, H.M., "State Compulsory Inspection Systems: The Pennsylvania Bureau of Traffic Safety, Harrisburg, 1968. 05049

Narrative to accompany a slide show depicting the operation of the Pennsylvania PMVI system.

Brenner, R., "The Changing Role of Motor Vehicle Inspection", National Highway Safety Bureau, Washington, 1970. (14362)

Suggestions for the improvement of vehicular safety enforcement measures.

Brenner, R., "State-of-the-art Motor Vehicle Inspection", National Highway Safety Bureau, Washington, 1970. (13115 A35)

Reviews of past approaches to auto inspection, current activities, and an overview of new directions for PMVI.

Bridenstine, W.M., "Compilation of State Motor Vehicle Inspection Laws and Regulations", Automobile Manufacturers Association, Inc., 1970. (15858)

A compilation of laws by state dealing with state motor vehicle inspection.

Burgess, H.W., "Periodic Compulsory, Motor Vehicle Inspection in Virginia", Traffic Digest and Review, Vol. 16, No. 5, May, 1968, p.8-11. (06952)

Procedures, public reaction to and some effects of Virginia's PMVI system.

Buxbaum, R.C., "The Relationship of Motor Vehicle Inspection to Accident Mortality Rates", (unpublished). (15263)

To examine the role of mechanical failure in auto accidents, motor vehicle mortality rates are compared in states which require and do not require auto inspection.

"California Vehicle Inspection - A Balanced Approach", California Highway Patrol, Sacramento, 1973. (28212)

An outline of three major inspection programs in California and an overview of the data which resulted in the adoption of a combination approach.

Cotton, T., "Motor Vehicle Inspection and Motor Vehicle Accident Mortality", American Journal of Public Health, Vol. 58, No. 6, June, 1968, p.1090-1099. (06758)

An investigation into the relation of PMVI and auto accident mortality.

"Compulsory Periodic Motor Vehicle Inspection", Automobile Club of Southern California, Los Angeles, 1966. (02635)

Arguments for compulsory motor vehicle inspection.

"Conference on Inspection Testing of Automobiles: Its Prospects for Accident Reduction", Washington University, St. Louis, 1968. (20838)

A collection of papers pertaining to various aspects of PMVI, especially the role it may play in increasing auto safety.

"Cost Effectiveness Study of Selected Motor Vehicle Inspection Systems for Michigan", Michigan State Police, 1972. (HSRI-30283)

An examination of Michigan motor vehicle inspection system; an evaluation of the cost effectiveness of various selected alternative systems.

Creighton, J., "Periodic Vehicle Inspection... "Why?", Motor Service Magazine, Chicago, 1965. (00711)

Arguments for periodic motor vehicle inspection.

Creswell, J.S., "An Evaluation of the Michigan Trial Substitute Motor Vehicle Inspection Program", HSRI, Ann Arbor, 1974. (29268)

Examines the effectiveness of an on-road, spot check method of conducting vehicle inspections.

Creswell, J.S., "The Michigan Trial Substitute Motor Vehicle Inspection Program", HIT LAB Reports, Vol. 4, No. 5, January, 1974, p.1-9.

Description of an experimental PMVI program designed to enchance check-lane effectiveness while minimizing costs.

"Costs and Benefits of Motor Vehicle Inspection", National Highway Safety Administration, Washington, 1975. (34073)

Costs of various types of motor vehicle inspection and the anticipated safety benefits of each.

"Data on Vehicle Inspection Programs for State Appointed Stations, State Owned and Operated Stations", American Association of Motor Vehicle Administrators, Washington, 1966. (05733)

Costs of inspections, number of vehicles tested, relationship of inspections to fatalities, percentages of defects found (by component).

Development of Techniques and Equipment to Improve Reliability of Automotive Diagnosis, Cline, E.L., Clayton Mfg. Co., El Monte, California, 1967. (HSRI 01566)

Development and use of automatic diagnostic techniques in auto inspection.

Durgea, H.A., "Random Motor Vehicle Inspection in California", Traffic Digest and Review, Vol. 16, No. 5, May, 1968, p.5-7. (06952)

Costs, procedures, and administration of California's PMVI system.

"Equipment for Emi-Automatic Vehicle Inspection Lane", Crypton-Triangle Ltd., 1973. (HSRI 32140 A05)

Discussion of equipment used in an advanced diagnostic test facility as developed in Great Britain in 1960.

"Florida Offical Vehicle Inspection Manual", Florida Highway Patrol, 1961. (06515)

Rules, regulations, and procedures for a statewide system of motor vehicle safety inspection conducted by privately operated garages in Florida.

"Compulsory Vehicle Inspection", Ford Motor Company, Dearborn, 1961. (11850)

Brief arguments for safety checks of autos.

Fuchs, V.R., "Motor Accident Mortality and Compulsory Inspection of Vehicles", New York City Health Services Administration, 1967. (03010)

The relation between accident mortality and compulsory auto inspection in examined by regressing age-standardized mortality ratios on inspection and other variables across states.

Grillo, J., "Status of Periodic Motor Vehicle Inspection Program", National Highway Traffic Safety Administration, Washington, 1975. (33116)

Tabular summary of status of PMVI programs by state.

Grime, G.G., "Inspection of Vehicles for Road Worthiness with Special Reference to Methods and Equipment", Proceedings of the Institution of Mechanical Engineers, No. 5, pp.129-158. (HSRI 02054)

Discussion of some considerations involved in inspection of motor vehicles, with special reference to the need of inspection, items to be checked, and frequency of inspection.

Goodwin, W.A., "Development of a Periodic Motor Vehicle Inspection System", Tennessee University, Knoxville, 1970. (14973)

Interim report recounting the first year's effort to develop a PMVI system for Tennessee. Discuss objectives compares types of systems, develops procedures and recommends facilities.

"Handbook for Installation and Inspection Stations", California Highway Patrol, Sacramento, 1969. (HSRI 14982)

An outline for the operation of pollution control equipment inspection stations.

"How to Operate Community Safety-Check Lanes", Auto Industries Highway Safety Committee, Inc., Washington, 1962. (05700)

"How to Plan and Conduct Your Vehicle Safety Check, National Vehicle Safety Check for Communities", Washington, 1961. (09835)

Organizing a motor vehicle safety inspection program in your city.

Hrebec, M.P., "Random Motor Vehicle Inspection in Michigan", Traffic Digest and Review, Vol. 16, No. 5, May, 1968, p.12-14. (06952)

Inception of program operating procedure, and costs of Michigan's PMVI system.

Hrebec, M.P., "State Compulsory Inspection Systems: Michigan System and Data Summary", Michigan Department of State Police, Lansing, 1968. (05051)

General discussion of effects of PMVI; tabular summary of Michigan program.

"Inspection Handbook for Passenger Cars, Trucks, and Buses, Motorcycles, School Buses, Foreign Vehicles", Motor Vehicle Manufacturers Association, Detroit, 1973. (14294)

Procedures for the inspection of cars, trucks, buses, and motorcycles.

"Inspection Laws Annotated", National Committee on Uniform Traffic Laws and Ordinances, Washington, 1969. (10403)

Development of state PMVI laws, annotation of laws by topic, texts of state inspection laws, text of highway safety program.

"Inspection of Motor Vehicles in Bloomington, Indiana and Monroe County", Ultrasystems, Inc., Newport Beach, California, 1972. (HSRI 27289)

Study of in-use motor vehicles through the use of a mobile inspection facility (van).

Kalin, S.R., "An Evaluation of the New Jersey Motor Vehicle Inspection System", Operations Research, Inc., Silver Spring, Md., 1970. (15861)

Covers: 1) administration, 2) compliance with standards, 3) operations and facilities, 4) quality audit, 5) enforcement.

King, R.B., "Vehicle Inspection", Safety on the Road, G.S. McClellan, ed., H.W. Wilson Co., 1966, p.132. (04719 A26)

Arguments for vehicle inspection.

Little, J.W., "The Fallacy of Evaluating Periodic Motor Vehicle Inspection by Death Rates", HSRI, Ann Arbor, 1968. (28843)

An analysis of the effect of PMVI on auto accident fatality rates in the U.S.

Little, J.W., "Federal Politics in State Vehicle Inspection Safety Programs", Arizona State Law Journal, Vol. 1969, No. 3, 1969, pp.341-368. (12497)

Describes how highway safety measures have become issues of federal-state politics, and presents a survey of the effect of the National Highway Safety Act of 1966 upon the adoption of PMVI programs by the states.

Little, J.W., "Motor Vehicle Inspection Legislation; A Survey of Patterns of Opposition", HSRI, Ann Arbor, 1967. (00654)

Results of a survey intended to determine the level of interest in and significant opposition to adopting motor vehicle inspection legislation.

Little, J.W., "Politics and Vehicle Inspection in the U.S.", HSRI, Ann Arbor, 1968. (07030)

A brief description of periodic motor vehicle inspection; a political history of PMVI.

Lowry, F.P., "Vehicle Condition and Peridoic Safety Inspections", Passenger Car Design and Highway Safety, Consumers Union of the U.A., 1962. (01888)

Arguments for the introduction of auto safety inspections.

MacCleary, R.E., "The Value of Periodic Motor Vehicle Inspection to Motorists", Automobile Manufacturers Association, Detroit, 1971 (15556)

Arguments for PMVI and suggestions as how to establish a workable program in your state. Statistical appendices.

"Mandatory Vehicle Inspection: Is It Worth the Cost?", Steel, December 4, 1967, pp.35-37. (013592)

A discussion of some benefits of PMVI.

"Manpower-Saved Inspection Station for Motor Vehicles", Ministry of Transport of Japan, Technical Aspects of Road Safety, 41, March, 1970, pp.3.1-3.14.

Suggestions for the integration of automatic diagnostic equipment into the motor vehicle inspection process in Japan.

"Manual of Official Inspection Station Instructions", Rhode Island Registry of Motor Vehicles, 1967. (HSRI-09009)

Establishes rules, regulations, and methods for use in an inspection program in Rhode Island to be carried out by service station operators.

Mayer, A.J., "Motor Vehicle Inspection: Report on Current Information, Measurement, and Research", Wayne State University, Detroit, 1963. (00650)

Analyses of current arguments for and against inspection; measurements of the relationship between inspection and auto death rate; and some research proposals.

A Maryland Periodic Motor Vehicle Inspection System (same as #8), pp.989-1135. (HSRI-17682 A02)

Outline of a proposed statewide system for auto safety inspection in Maryland.

"Methods to Achieve Standardization of Automotive Diagnostic Testing", Standardization of Automotive Diagnostic Testing, National Motor Vehicle Safety Advisory Council, Washington, D.C., 1972, Paper No. 72018. (HSRI-19300 A18)

A wide collection of conference papers on diagnostic testing arranged under these topics: (1) system concepts, (2) candidate systems for diagnosis, (3) diagnostic techniques, (4) standardization of diagnostic techniques, (5) future diagnostic programs.

"Mobile Inspection Equipment and Techniques", RCA Service Company, Camden, N.J., 1970. (HSRI-15192)

The testing of a mobile, self-sufficient facility for the safety inspection of autos.

"Motor Vehicle Inspection and Road Safety", Medical Journal of Australia, Vol. 2, September 17, 1966, pp.567-568. (22289)

A short review of others' finding in the field of auto inspection as relating to accident mortality.

"The Motor Vehicle Inspection Experiment", California Highway Patrol, Sacramento, 1974. (32789)

Description of a one-year motor vehicle inspection experiment in California designed to ascertain the effect that various levels of inspection have on the maintenance of vehicles.

"The Motor Vehicle Inspection Program and Its Relationship to Highway Safety in New Jersey", New Jersey State Division of Motor Vehicles, 1963. (01256)

The effect of the motor vehicle inspection program in New Jersey in reducing accidents and fatalities.

"Motor Vehicle Inspection Project", North Atlantic Treaty Organization, Committee on the Challenges of Modern Society, Brussels, 1974. (HSRI-30660)

A report on the institutions in charge of inspection and the qualification and training of inspectors in five NATO countries.

"Motor Vehicle Inspection Station Manual", Wisconsin Motor Vehicle Department, Madison, 1960. (08321)

Rules, regulations, and procedures for a statewide motor vehicle safety inspection in Wisconsin.

"Motor Vehicle Safety Inspection and Reference Manual", Chek-Chart, San Jose, California, 1975. (I HSRI-32039; II 32676)

Illustrated list of points to be inspected for auto safety.

Motor Vehicle Safety Inspection in Perspective, Arizona Highway Department, 1965. (03699)

A review of Arizona's inspection program.

Nagler, L.H., "Periodic Motor Vehicle Inspection for Michigan", American Motors Corp., Detroit, 1964. (01515)

Arguments for the institution of a motor vehicle inspection program in Michigan.

"National Car Check Campaign", Canada Safety Council, Ottawa, 1967. (08897)

A campaign to encourage the safety inspection of motor vehicles by their operators.

"National Highway Traffic Safety Administration Traffic Safety Program Brake Inspection Methods Study", AAMVA 73 Presentations, Washington, 1973. (HSRI-29664 A04)

Engineering aspects of auto brake inspection and testing with discussion of testing equipment available.

O'Day, J., "The Breakdown of Periodic Motor Vehicle Inspection", Proceedings, Canadian Highway Safety Council Conference, 1968.

Development of a model to predict the effectiveness of the various alternative forms of PMVI available.

O'Day, J., "A Modeling Approach to Motor Vehicle Inspection", HSRI, Ann Arbor, 1967. (03200)

A model is developed relating vehicle inspection to the occurence of highway accidents.

"Official Inspection Station Rules and Regulations", Pennsylvania Bureau of Traffic Safety, 1966. (HSRI-08312)

Sets forth rules and regulations for the operation of a motor vehicle inspection system in Pennsylvania and suggests methods of inspection.

"Oklahoma Official Motor Vehicle Inspection Rules and Regulations Manual", Oklahoma Department of Public Safety, 1960. (09387)

Rules, regulations, and procedures for a statewide motor vehicle safety inspection in Oklahoma.

Oldham, F.B., "Vehicles in Use, and State Compulsion Vehicle Inspection", Automobile Club of St. Louis, 1970. (14871)

Age and condition of vehicles in use; defect rates found by component; results of braking tests.

Keranen, T.W., "Passenger Vehicle and Light-Truck Braking Systems Inspection Equipment", Bendix Corp., Southfield, Michigan, 1973. (HSRI-28764)

A program to determine the methods and specifications for a brake inspection system and an evaluation of existing inspection equipment.

"Passenger Vehicle Inspection", California Highway Patrol, Sacramento, 1967. (08962)

How the California PMVI system is administered and operated.

Periodic Inspection Manual, Vermont Department of Motor Vehicles, 1965. (08277)

Rules, regulations, and procedures for the inspection of autos in Vermont.

Periodic Motor Vehicle Inspection, Automobile Property Damage and Consumer Information Program, GPO, Washington, D.C., 1972, pp.931-988. (HSRI-17682 A01)

Suggestions for the design of a facility to inspect 50 auto safety factors and measure atmospheric emissions.

"Preliminary Estimate of Traffic Fatalities, 1959; States With and Without Inspection Programs", National Automobile Dealers Association, 1960. (03337)

Tabulation showing that states with inspection programs have a slightly lower accident fatality rate.

"Program Plan for the Michigan Trial Substitute Motor Vehicle Inspection System", Michigan State Police/HSRI, Ann Arbor, 1971. (17703)

Contains general inspection procedures, evaluation procedures, evaluation problems, and specific measurement techniques.

"A Proposal for a Periodic Motor Vehicle Inspection for California", Research Institute of Diagnostic Engineering, Livonia, Michigan, 1961. (06375)

Administration and costs of a state-wide motor vehicle inspection program for California.

Reinfurt, D.W., "Periodic Motor Vehicle Inspection in North Carolina", North Carolina University, Chapel Hill, Highway Safety Research Center, 1971. (17584)

Presents statistics for first year of state PMVI relating to failure rates and repair costs, and relationship to auto age.

Reinfurt, D.W., "Statistical Techniques for Evaluating the Effectiveness of State Motor Vehicle Inspection Programs in Reducing Highway Accidents", North Carolina University, Chapel Hill, 1974. (30130)

Using accident and inspection data from South Carolina and Florida, the effect of periodic motor vehicle inspection on highway accidents in investigated. Since the data are limited, the statistical methodologies employed are major points of interest.

"Report on Recommendations Regarding Motor Vehicle Inspection", Coverdale and Colpitts, New York, 1967. (03533)

Evaluation of auto inspection accomplishments; recommendation of what could be accomplished through such a program.

"Reports on Three State Motor Vehicle Inspection Programs", Traffic Digest and Review, Vol. 16, No. 5, May, 1968, p.4-15. (06952)

Description and statistical summary of PMVI systems in California, Virginia, and Michigan.

Foldvary, L.A., "A Review of Vehicle Inspection in Relation to Road Safety", Expert Group on Road Safety, Melbourne, 1973. (30844)

A review of the need for inspection, the contribution of defects to accidents, and procedures and standards for a motor vehicle inspection system.

"Rules and Regulations and Instructions for Official Vehicle Inspection Stations", Utah Department of Public Safety, 1966. (08270)

"Rules and Regulations on Motor Vehicle Inspections", New Jersey Bureau of Vehicle Inspection, Trenton, 1966. (08998)

As title implies.

Rules, Regulations, and Requirements for Motor Vehicle Inspection Stations, Colorado Department of Revenue, Denver, 1965. (08269)

"Safety Inspection of the Highway and the Vehicle", Tennessee University, Highway Research Record, No. 376, 1971, pp.21-28. (HSRI-50676 A06)

A description of two general approaches to the instituting of a motor vehicle inspection program; also, highway inspection techniques to spot traction trouble areas.

Sherman, H.W., "Sampling of Driver Opinions Toward Periodic Motor Vehicle Inspection", Highway Research Record, No. 420, 1972, p.36-43. (51061)

Sampling of motorists opinion regarding PMVI indicates favorable attitude.

"The Status of Motor Vehicle Inspection", Parker, G.L., International Days of Road Safety, Brussels, 1973. (HSRI-32140 A06)

Summary of technology and standards applied in motor vehicle safety testing in the U.S.

"A Study of Motor Vehicle Inspection", AAA Foundation for Traffic Safety, 1967. (02243)

Past, present, and future of auto inspection; effectiveness of inspection in accident prevention.

Symons, M.J., "A Model for Evaluating the Effectiveness of Motor Vehicle Inspection Programs", Accident Analysis and Prevention, Vol. 7, No. 4, December, 1975, pp.281-288.

A statistical model based on the assumption that waiting time between accidents follows an exponential distribution is presented for the evaluation of PMVI programs in reducing highway accidents.

Coucke, E., "Technical Aspects of Road Safety: Vehicle Fitness", Fonds d'Etudes et de Recherches aw Probleme de la Securite Routiere, Brussels, 1973. (01466)

Technical inspection of motor vehicles as it is practical in different countries.

Terry, R.M., "Periodic Motor Vehicle Inspection", Virginia Department of State Police, Richmond, 1969. (14068)

The effect of the Highway Safety Act of 1966 on the adoption of PMVI by various states, and an overview of several state's programs.

Tully, D.J., "The Nova Scotia Compulsory Motor Vehicle Inspection Program", Nova Scotia Department of Highways, 1968. (06789 A02)

Justification of programs, costs, summary statistics.

Little, J.W., "Two-Month Survey of Motor Vehicle Inspection", HSRI, Ann Arbor, 1966. (HSRI-01507)

Contains a survey of past inspection activity, points out problems in motor vehicle inspection process, and suggests future research activities.

USA Standard Station Requirements for Inspection of Motor Vehicles, Trailers, and Semitrailers in Stations Owned and Operated by Regulatory Authority, United States of America Standards Institute, New York, 1968. (HSRI-13561)

McMinn, R.W., "Using Accident Research to Evaluate Periodic Motor Vehicle Inspection", New Jersey State Division of Motor Vehicles, Trenton, 1973. (28244)

The evaluation and costs of New Jersey's vehicle inspection program are described.

"Vehicle Check Lane Activity", Michigan State Police, East Lansing, 1971. (15244)

Statistical summary of inspection activity in Michigan, 1967-1970.

"Vehicle Inspection Procedure", West Virginia Motor Vehicle Inspection Bureau, Charleston, 1960. (08260)

Rules, regulations, and procedures for a statewide motor vehicle safety inspection in West Virginia.

"Vehicle Safety Inspection State Programs Bolstered by Federal Legislation", Automotive Information, February, 1967, p.8. (HSRI-23924)

Short discussion of need for periodic motor vehicle inspection and sources of inspection procedure techniques and standards.

"Weak Points of Cars; Periodic Inspection of Private Cars", AB Svensk Bilprovning (Sweden), 1973. (13176)

A tabular summary of the incidence of failure of the components necessary for the safe operation of 24 different auto models from 1966 to 1970.

APPENDIX F

STATISTICAL METHODS

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STATISTICAL METHODS

For testing whether the samples from the two counties had the same distribution on some variable, the chi-squared test was used. This was also the technique used to test whether a sample was representative of that county's registered vehicles. For example, consider the variable vehicle type. The data are given in Table A- . The null hypothesis is that the properties of vehicles in ofeach vehicle type is the same in the twc counties. The test statistic is:

$$X^2 = \sum_i \sum_j \frac{(X_{ij} - E(X_{ij}))^2}{E(X_{ij})}$$

i = vehicle type indicator

j = county indicator

where $$E(X_{ij}) = \frac{(\sum_i X_{ij})(\sum_j X_{ij})}{\sum_i \sum_j X_{ij}}$$

This statistic was used to compare the distributions of vehicles in the two counties. It was also used to compare the sample to the population of registered vehicles in each county and to compare the combined sample to the state.

A more complex statistical procedure based on weighted least squares was used to estimate trend lines relating the proportion defective vehicles to the age of the vehicle. This approach was also used in the

detailed analysis of the comparison of the wheel pull to the moving stopping test. It is described briefly below.

For purposes of analysis, the data can be regarded as independent binomial response variables representing the number of failures within each of the seventeen specified vehicle age categories. Since neither the failure rates nor the sample sizes are constant across the vehicle ages, the estimates of variance associated with these failure rates are unequal. As a result, the regression equation parameters can be estimated by a weighted least squares algorithm such as the computer program GENCAT discussed in Landis, et. al.[1] Within this framework, the probability vector $\underset{\sim}{p}$ is the 34 x 1 vector of observed proportions associated with the frequencies in Table To avoid matrix singularities, cells with entries of zero were changed to 0.5. Then the function vector of interest is the 17 x 1 vector of failure rates.

$$\underset{\sim}{y} = \underset{\sim}{F}(\underset{\sim}{p}) = \underset{\sim}{A}\underset{\sim}{p}$$

where $\underset{\sim}{A} = (0\ 1) \otimes \underset{\sim}{I}_{17}$, $\otimes$ denotes Kronecker product of matrices and $\underset{\sim}{I}m$ is the m x m identity matrix.

We are now interested in using the vector of failure rates $\underset{\sim}{y}' = (p_1, p_2, \ldots, p_n)$ and its symmetric variance-covariance matrix $\underset{\sim}{V}$ to fit a regression model via weighted least squares. The elements of $\underset{\sim}{V}$ are computed as follows:

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[1]Landis, J. Richard, W.M. Stanish, and Gary G. Koch: A Computer Program for the Generalized Chi-Square Analysis of Categorical Data Using Weighted Least Squares to Compute Wald Statistics (GENCAT), Biostatistics Technical Report No. 8, Dept. of Biostatistics, Univ. of Michigan, Ann Arbor, Michigan February 1976.

$$v_{ij} \begin{cases} 1/n_i \; p_i(1-p_i) , & \text{if } i = j \\ 0, & \text{if } i \neq j \end{cases}$$

for $i,j = 1, 2, \ldots, 17$. The regression model is of the form $E\{\underset{\sim}{y}\} = \underset{\sim}{X}\underset{\sim}{B}$ where $\underset{\sim}{B}$ is the t x 1 vector of coefficients and $\underset{\sim}{X}$ is the s x t design matrix. The value of t is the number of coefficients (or effects) to be estimated in the model. Accordingly, the vector of estimated coefficients can now be calculated by

$$\underset{\sim}{\hat{B}} = (\underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{X})^{-1} \; \underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{y}.$$

Moreover, the estimated variance-covariance matrix of these parameter estimates is given by

$$\underset{\sim}{V}_{\underset{\sim}{\hat{B}}} = \underset{\sim}{A}\underset{\sim}{V}^{-1} \; \underset{\sim}{A}' = (\underset{\sim}{X}'\underset{\sim}{V}^{-1} \; \underset{\sim}{X})^{-1}.$$

We can now generate the vector of fitted failure rates $\underset{\sim}{\hat{y}} = \underset{\sim}{X} \; \underset{\sim}{B}$ together with their estimated variance-covariance matrix

$$\underset{\sim}{V}_{\underset{\sim}{\hat{y}}} = \underset{\sim}{X}(\underset{\sim}{X}'\underset{\sim}{V}^{-1} \; \underset{\sim}{X})^{-1} \; \underset{\sim}{X}'.$$

A lack of fit statistic associated with this regression model can be obtained by computing

$$\begin{aligned} Q = SSE &= SSTO - SSR \\ &= \underset{\sim}{y}'\underset{\sim}{V}^{-1} \; \underset{\sim}{y} - \underset{\sim}{B}'\underset{\sim}{X}'\underset{\sim}{V}^{-1} \; \underset{\sim}{y} \end{aligned}$$

which has a Chi-square distribution with 17-t degrees of freedom under the assumption that the model is apt. If Q is non-significant (the model fits) then specific model effects can be tested. Otherwise, if Q is significant, the tests for specific effects are meaningless and another model should be tried.

Tests for the specific effects can be conducted using contrast matricies. The hypotheses for these tests take the form: $H_o: \underset{\sim}{C}\underset{\sim}{B} = \underset{\sim}{0}$, where $\underset{\sim}{C}$ is a c x t contrast matrix which selects the desired effects to be tested from $\underset{\sim}{B}$. The test statistic thus can be derived as

$$\underset{\sim}{Q}_m = (\underset{\sim}{C}\hat{\underset{\sim}{B}})'(\underset{\sim}{C}(\underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{X})^{-1}\underset{\sim}{C}')^{-1}\ (\underset{\sim}{C}\hat{\underset{\sim}{B}})$$

which tests the amount Q would be increased if the constraints implied by $\underset{\sim}{C}$ were not in the model. Finally an analogue to the multiple R^2 in standard regression analysis can be calculated as

$$R^2 = SSR\ /\ SSTO = Q_m/\ (Q + Q_m)$$

when the statistic Q_m tests for all effects to be simultaneously zero.

For our example, we wish to examine the fit of three different polynomial models to the data: linear, quadratic, and cubic. The models used and the coefficient matrices are as follows:

$$\begin{aligned} Y &= B_o + B_1X + e & \underset{\sim}{B}' &= (B_o, B_1) \\ Y &= B_o + B_1X + B_2X^2 & \underset{\sim}{B}' &= (B_o, B_1, B_2) \\ Y &= B_o + B_1X + B_2X^3 + e & \underset{\sim}{B}' &= (B_o, B_1, B_2, B_3) \end{aligned}$$

with t = 2,3,4 respectively. The design matrices used for the regression are all derived from the matrix used for the cubic regression:

$$\underset{\sim}{X}_c = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 \\ 1 & 2 & 4 & 8 \\ 1 & 3 & 9 & 27 \\ 1 & 4 & 16 & 64 \\ 1 & 5 & 25 & 125 \\ 1 & 6 & 36 & 198 \\ 1 & 7 & 49 & 343 \\ 1 & 8 & 64 & 512 \\ 1 & 9 & 81 & 729 \\ 1 & 10 & 100 & 1000 \\ 1 & 11 & 121 & 1331 \\ 1 & 12 & 144 & 1728 \\ 1 & 13 & 169 & 2179 \\ 1 & 14 & 196 & 2744 \\ 1 & 15 & 225 & 3375 \\ 1 & 16 & 256 & 4096 \end{bmatrix}$$

The design matrix for the linear model is the 17 x 2 matrix consisting of the first two columns of X_c and that of the quadratic the 17 x 3 matrix of the first three columns.

A test for the slope of zero in the model with only the linear term is done with a contrast matrix $\underset{\sim}{C}_1 = (0\ 1)$. The contrast matrix for the test that both the linear and quadratic effects are zero (SSR) is

$$\underset{\sim}{C}_2 = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

with specific effects tested by the two 1 x 3 matrices consisting of the individual rows of C_2. Finally, for the cubic model the test that the simultaneous effects are zero (SSR) is obtained by using the contrast matrix

$$\underset{\sim}{C}_3 = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

with specific effects tested by the individual rows of $\underset{\sim}{C}_3$.

The results of this analysis (Table F-1) indicate that although the cubic equation gives the best fit ($R^2 = 0.9975$), the individual cubic effect is non-significant so a quadratic model is more appropriate. The final model with estimated proportions and standard errors, observed proportions, and residuals is given in Table F-2.

It was also hypothesized that there might be a linear trend over a reduced range of the data, namely the ages 0 to 11 years. In a similar manner as before, the design matrix became the first twelve rows of the previous design matrix with the appropriate columns corresponding to the linear and quadratic effects. The results of this regression (Table F-2) again imply that the quadratic model is the most appropriate. The observed proportions, estimated proportions, and standard errors, and residuals are given in Table F-4.

Although point estimates of the three conditional probabilities that are of primary interest can be easily derived from the data, interval estimates were also desired. Thus the eight possible brake inspection outcomes and their frequencies were arranged as in Table two. The covariances of the means of the first four categories were derived from their multi-nomial structure. The means and their covariances were then combined to yield the three estimates of the probability that a serious brake defect will be discovered by a wheel pull inspection for vehicles that had passed the stopping test and their variances. The multivariate Hotelling's T

statistic was then used to yield three simultaneous confidence intervals of the appropriate width.[1]

Point estimates of the three conditional probabilities that a serious brake defect will be discovered by a stopping test for vehicles that had passed the wheel pull inspection were derived in table three. The Bonferroni procedure was used to obtain three simultaneous confidence intervals of the appropriate width.[2]

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[1]Harris, Richard J. A Primer of Multivariate Statistics. New York: Academic Press, Inc. 1975, p. 73.

[2]Neter, John and Wasserman, William. Applied Linear Statistical Models. Homewood, Illinois: Richard D. Irwin, Inc. 1974 p. 147.

Table F-1

Fitted Models for the Total Vehicle, Complete Range

Model: $Y = B_0 + B_1X + e$

Parameters	Estimated Parameters	Standard Error
B_0	0.1185	0.006354
B_1	0.07697	0.001053

Source	d.f.	X^2	p	
Regression	1	5344.66	0.0000	
Error	15	441.56	0.0	$R^2 = 0.92369$

Model: $Y = B_0 + B_1X + B_2X^2 + e$

Parameters	Estimated Parameters	Standard Error
B_0	-0.01765	0.009167
B_1	0.14853	0.003629
B_2	-0.00588	0.000285

Source	d.f.	X^2	p	
Regression	2	5769.18	0.0	
Linear	1	1674.97	0.0	
Quadratic	1	424.53	0.0	
Error	14	17.04	0.254	$R^2 = 0.99706$

Model: $Y = B_o + B_1X + B_2X^2 + B_3X^3 + e$

Parameters	Estimated Parameters	Standard Error
B_0	-0.03117	0.012650
B_1	0.16015	0.008324
B_2	-0.00798	0.001382
B_3	0.00010	0.000065

Source	d.f.	X^2	p	
Regression	3	5771.59	0.0	
Linear	1	370.14	0.0	
Quadratic	1	33.32	0.0	
Cubic	1	2.41	0.1209	
Error	13	14.63	0.3309	$R^2 = 0.99747$

Table F-2

OBS & Fitted Values under Full Range Quadratic Model

Observed	Predicted	s.e.	Residual
0.18182	-0.017649	0.009167	0.035831
0.113930	0.12500	0.006506	-0.011067
0.25608	0.25589	0.004873	0.000194
0.37888	0.37502	0.004397	0.003858
0.49650	0.48239	0.004670	0.014104
0.59025	0.57800	0.005191	0.012247
0.63507	0.66185	0.005552	-0.026784
0.73607	0.73394	0.005706	0.002130
0.88080	0.79427	0.005743	0.006532
0.84420	0.84244	0.005903	0.001363
0.88571	0.87965	0.006547	0.006065
0.89630	0.90470	0.007983	-0.008402
0.87500	0.91799	0.000299	-0.042988
0.86792	0.91952	0.013433	-0.051593
0.90476	0.90929	0.017304	-0.004525
0.96000	0.88730	0.021852	0.072704
0.95238	0.85355	0.027039	0.098835

Table F-3

Fitted Models for the Reduced Range, Total Vehicle

Model: $Y = B_0 + B_1X + e$

Parameters	Estimated Parameters	Standard Error
B_0	0.088318	0.006653
B_1	0.085708	0.001199

Source	d.f.	X^2	p	
Regression	1	5107.29	0.0	
Error	10	206.16	0.0	$R^2 = 0.96120$

Model: $Y = B_0 + B_1X + B_2X^2 + e$

Parameters	Estimated Parameters	Standard Error
B_0	-0.02183	0.010287
B_1	0-15099	0.004802
B_2	-0.00609	0.000434

Source	d.f.	X^2	p	
Regression	2	5304.36	0.0	
Linear	1	988.51	0.0	
Quadratic	1	197.06	0.0	
Error	9	9.10	0.4281	$R^2 = 0.99829$

Table F-4

Observed and Fitted Values Under the Quadratic Model, Reduced Range

Observed	Predicted	s.e.	Residual
0.01818	-0.02182	0.010287	0.040010
0.11393	0.12307	0.006765	-0.009132
0.25608	0.25578	0.004885	0.000307
0.37888	0.37631	0.004764	0.002571
0.49650	0.48466	0.005417	0.011840
0.59025	0.58082	0.005951	0.009427
0.63507	0.66480	0.006084	-0.029738
0.73607	0.73661	0.005899	-0.000535
0.88080	0.79623	0.005823	0.004577
0.84420	0.84366	0.006637	0.000541
0.88571	0.87892	0.008910	0.006798
0.89630	0.90199	0.012595	0.005692

Table F-5

Brake Inspection Analysis

	Analysis Categories*								
Police	+	+	+	+	-	-	-	-	
HSRI 1	+	-	+	+	+	-	+	+	
HSRI 2	+	-	-	+	+	-	-	+	
HSRI 3	+	-	-	-	+	-	-	-	
Total	1749	62	52	24	491	44	31	12	= 2465
	1887				578				

From Table C-5,

* + denotes pass
- denotes fail

$$\bar{\underline{X}} = \frac{1}{1887} \begin{pmatrix} 1749 \\ 62 \\ 52 \\ 24 \end{pmatrix} = \begin{pmatrix} 0.927 \\ 0.033 \\ 0.027 \\ 0.013 \end{pmatrix}.$$

Let $x_i = \begin{cases} 1 \text{ if } x \text{ falls in the } i\text{th classification} \\ 0 \text{ otherwise} \end{cases}$

then $\text{var}(\bar{X}_i) = \frac{p(X_i=0)\ p(X_i=1)}{n}$, $\text{cov}(\bar{X}_i, \bar{X}_j) = \frac{-p(X_i=1)\ p(X_j=1)}{n}$,

so

$$S_{\bar{X}} = \begin{pmatrix} 3.592 & -1.614 & -1.354 & -0.625 \\ -1.614 & 1.684 & -0.048 & -0.022 \\ -1.354 & -0.048 & 1.420 & -0.018 \\ -0.625 & -0.022 & -0.018 & 0.665 \end{pmatrix} \times 10^{-5}.$$

Now,

$$\underline{p} = A\bar{\underline{X}},$$

where

$$A = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 \end{pmatrix},$$

and $\underline{p}$ = vector of proportions of interest

The results are

$P_1 = 0.033$, $\quad var(P_1) = (4.104 \times 10^{-3})^2$,

$P_2 = 0.060$, $\quad var(P_2) = (5.485 \times 10^{-3})^2$,

$P_3 = 0.073$, $\quad var(P_3) = (5.993 \times 10^{-3})^2$,

where $var(P_i) = \underline{a}_i \, S_{\underline{x}} \, \underline{a}_i'$.

The joint

95% confidence interval width = $T_{critical} \sqrt{\underline{a} \, S_{\underline{x}} \, \underline{a}'}$.

Using this one

$0.020 \leq P_1 \leq 0.046$

$0.043 \leq P_2 \leq 0.077$

$0.054 \leq P_3 \leq 0.091$

for the joint 95% confidence intervals.

Here,

$$T_{critical} = \sqrt{\frac{F(.95;P,N-P)\ P(N-1)}{N-P}}$$

$T_{critical} = 3.088$ $\qquad P = 4$

$\qquad\qquad\qquad\quad N = 1887$

Table F-6

$H_1 = 0.226$ $\quad$ $\text{var}(H_1) = (8.61 \times 10^{-3})^2$

$H_2 = 0.221$ $\quad$ $\text{var}(H_2) = (8.69 \times 10^{-3})^2$

$H_3 = 0.219$ $\quad$ $\text{var}(H_3) = (8.74 \times 10^{-3})^2$

where $\text{var}(H_i) = \dfrac{p(H_i=0)\ p(H_i=1)}{n_i}$

95% confidence interval width = Z critical $\sqrt{\text{var}(H_i)}$

$0.205 \leq H_1 \leq 0.247$ $\quad$ $Z(0.9917) = 2.395$

$0.200 \leq H_2 \leq 0.242$

$0.198 \leq H_3 \leq 0.240$

Alternative Methods for Performing Weighted Least Squares Analysis. The program used and described in the preceding sections, GENCAT, is not always available or familiar to researchers. This section describes how an ordinary least squares regression program--exemplified by the REGRESS command in the University of Michigan's MIDAS package of statistical programs--can be used to perform weighted least squares model fitting.

Many model fitting techniques rely on the principle of least square(LS). The usual regression models and analysis of variance models are of this type. The principle of least squares is to estimate parameters in such a way that the square of the vertical distance between the observed values and the values predicted by the model is a minimum.

For example, such a model is

$$Y = \beta_0+\beta_1\chi_1+\beta_2\chi_2+\varepsilon \ ,$$

where the β's are parameters, $\chi_1$and $\chi_2$are observed values of the independent variables, Y is the dependent variables, and ε represents a random error. The predicted value of Y is

$$\hat{Y} = b_0+b_1X_1+b_2X_2 \ ,$$

where the b's are estimates of the β's. If the method of least squares is used, the b's are chosen so that $\Sigma(\hat{Y}-Y)^2$ is a minimum.

The usual assumptions about the error terms are that they (1) have mean zero, (2) have constant variance,(3) are independent, and (4) are normally distributed. The first of these assumptions implies that the model is unbiased--that is, that the "correct" model is being used. The second and third assumptions are necessary to the appropriateness of the LS technique. The fourth assumption is necessary in order to infer sampling distributions of the estimates, test statistical hypotheses, and form confidence intervals.

If the second or third assumption is violated, then the LS method of parameter estimation may not be appropriate. The LS technique treats all data as equally reliable. If the variances are not constant, this is not the case. One or few observations which are "outliers" will charge the estimated model considerably. If the variances are not constant, the data points which are least reliable (have the largest variances) are most likely to give values which are "outliers". Thus if variances are not constant, relatively unreliable observation may drastically affect the model.

A similar situation occurs when the errors are not independent. In this case, the error at one point influences the error at another and the effect may cumulate. Here again LS may be misleading.

One alternative when assumption (2) or (3) is not met is to use weighted least squares (WLS). Assume first that the covariance matrix of the e's is a general covariance matrix $\underline{V}$. Let $\underline{V}^{-1}$ denote its inverse ($\underline{V}$ is assumed to be symmetric and of full rank). Let $\underline{P}$ be an orthogonal matrix such that $\underline{P}\ \underline{V}\ \underline{P}' = \underline{I}$, so that $\underline{P}'\underline{P} = \underline{V}^{-1}$. Let $\underline{Z} = \underline{P}\ \underline{Y}$, $\underline{\delta} = \underline{P}\underline{\varepsilon}$ and $\underline{W} = \underline{P}\ \underline{X}$. Then the transformed problem $\underline{Z} = \underline{W}\ \beta + \underline{\delta}$ may be modeled by LS, since the covariance matrix of $\underline{\delta}$ becomes $\underline{P}'\underline{V}\ \underline{P} = \underline{I}$. For a general covariance matrix $\underline{V}$, determination of $\underline{P}$ may be quite tedious. However, if the errors are independent, but have different variances, $\underline{V}$ is diagonal with the variances as the diagonal entries. In this case, $\underline{P}$ is the diagonal matrix with the inverse of the square roots of the variances as its diagonal entries.

The transformed problem results in choosing the parameters to mimimize

$$\sum_i \sum_j w_{ij}(\hat{Y}_i - Y_i)(\hat{Y}_j - Y_j) ,$$

where w_{ij} are the elements in $\underline{V}^{-1}$. If $\underline{V}$ is diagonal, i.e., if the errors are independent, this reduces to

$$\sum_i w_i^2(\hat{Y}_i - Y_i)^2 \quad ,$$

where $w_i^2 = \frac{1}{\sigma_i 2}$ are the inverses of the variances.

There are a number of applications where the WLS techniques may be appropriate. The most frequent may be the case of proportions. The variance of a sample proportion is $Var(\hat{p})=\frac{pq}{n}$, which may vary considerably, particularly if the sample size also varies. A second case of application is data which are means based on different sample sizes, in which case $Var(\bar{X}) = \frac{\sigma^2}{n}$. A final example is counts or frequencies, where the variance may be proportional to the mean (or observed response).

In principle, both the GENCAT and MIDAS routines may be utilized to perform WLS. However, these are different approaches and different restrictions apply. GENCAT is limited to the case of proportions or some functions of proportions, but the basic covariance structure must be that of proportion. Aside from that, the method is general and may be utilized by entering either the vector of proportion and its covariance matrix or the vector of parameters and its covariance matrix into the program. Thus $\underline{V}$ may be quite general.

In MIDAS, WLS is accomplished by a series of transformations followed by LS on the transformed data. Thus it is necessary to know $\underline{V}^{-1}$ in the form $\underline{P}'\underline{P}$. Even then, for a general $\underline{V}$, it may be very difficult to accomplish the transformations $\underline{P}\ \underline{Y}$, $\underline{P}\ \underline{X}_{ij}$, for the dependent variable $\underline{Y}$ and all the independent variables X_i (including dummy variables). If the errors are independent, however, this can be accomplished readily.

The MIDAS Method. Assume that the errors have variances of the form $Var(\varepsilon_i) = \sigma^2 v_i$, where the v_i are different.

Then let $w_i = \frac{1}{v_i}$. Transform the dependent variable Y by $Y_i' = \sqrt{w_i} Y_i$. Likewise, transform each independent variable $X_i' = \sqrt{w_i} X_i$. Also create a new variable $\sqrt{w_i}$. This will be used to obtain the estimate of β_0. After these transformations, use the REGRESS command with OP=MEANZERO. The resulting coefficients are the WLS estimates of the coefficients in the original model.

Example

Suppose we wish to fit a quadratic regression to proportional data. The dependent variable is the proportion of vehicles failing an inspection and the independent variable is the age of the vehicle. The model is

$$Y_i = \beta_0 + \beta_1 X_i + \beta_2 X^2 + \varepsilon_i \quad , \qquad (1)$$

where the variance of ε_i is not constant, but has the form $Var(\varepsilon_i) = k \frac{P_i(1-P_i)}{n_i}$. (If the variances are known, k can be made equal to 1.).

Multiply both sides of the equation (1) by $\sqrt{w_i} = \sqrt{\frac{n_i}{P_i q_i}}$ to get

$$Y_i' = \beta_o \sqrt{w_i} + \beta_1 X_i' + \beta_2 X_i'^2 + \varepsilon_i' \quad ,$$

where

$$Y_i' = \sqrt{w_i}\, Y_i$$
$$X_i' = \sqrt{w_i}\, X_i$$
$$X_i'^2 = \sqrt{w_i}\, X_i^2$$
$$\varepsilon_i' = \sqrt{w_i}\, \varepsilon_i$$

With Data in the form:

V1 Age

V2 Number Failing

V3 Total Vehicles in Age Class

The following MIDAS procedure will perform Weighted Least Squares Regression on the Data.

Command	(Comments)
Trans V4=V2/V3	(p_i = percent failing)
Trans V5=V1**2	(square of age)
Trans V6=1-V4	($i - p_i$)
Trans V7=V4*V6	($p_i(1-p_i)$)
Trans V7=1/V7	$\left(\frac{1}{p_i(1-p_i)}\right)$
Trans V7=V3*V7	$\left(\frac{n_i}{p_i(1-p_i)} = W_i\right)$
Trans V8=SQRT(V7)	($\sqrt{W_i}$)
Trans V9=V8*V4	($\sqrt{W_i}$ p_i = Y')
Trans V10=V8*V1	($\sqrt{W_i}$ age = X')
Trans V11=V8*V5	($\sqrt{W_i}$ age^2 = X'^{2})
Regress V=9, 8, 10, 11	OP=MEANZERO
Save V12=Predict	($\hat{Y}' = \sqrt{W_i}$ $\hat{Y}$)
Save V13=Residual	($e' = \sqrt{W_i}$ e)
Trans V14=V12/V8)	($\hat{Y} = \hat{P}$)
Scatter V=13; 1, 12, 14	Resid vs. Age, $\hat{Y}$, $\hat{Y}$
Scatter V-4, 14; 1	p & $\hat{p}$ vs. Age
Write V=1-4, 7, 13, 14	FO=3F6, F16.1, 3F13.6

Age, Fail, Total, Weight, Residual (Weighted) Predicted

1975 Total Sample Regression Data

Age	#Fail	Total
0	0 (0.5)	27 (27.5)
1	148	1299
2	484	1890
3	757	1998
4	850	1712
5	690	1169
6	623	981
7	753	1023
8	599	748
9	466	552
10	341	385
11	242	270
12	126	144
13	46	53
14	38	42
15	12	12 (12.5)
16	10	10 (10.5)

Values in parentheses are the values used in the program.

Note that:

$$\mathrm{Var}(\varepsilon_i') = \mathrm{Var}(\sqrt{w_i}\,\varepsilon_i) = W_i \mathrm{Var}(\varepsilon_i) = \frac{n_i}{P_i(1-P_i)} \cdot \frac{P_i(1-P_i)}{n_i} \cdot k = k,$$

so that ε_i' has constant variance as desired. Then with a new variable with values $\sqrt{w_i}$, and options = mean zero, MIDAS polynomial regression will give the WLS estimate at β_0, β_1, and β_2 .

The results from MIDAS are:

	Coefficients	Standard errors
b_0 =	-0.017649	0.010113
b_1 =	0.14853	0.0040036
b_2 =	-0.00588	0.0003148

MIDAS also calculates an estimate of k which is the error mean square (here k=1.21696). Also, a multiple correlation coefficient or coefficient of determination is presented.

R^2 = 0.99653, where $R^2 = \left[\mathrm{Correlation}(\sqrt{w_i}P_i,\ \sqrt{w_i}\hat{P}_i)\right]^2$.

The results from an ordinary (LS) regression on these data were:

	Coefficient	Standard error
b_0 =	0.02477	0.035373
b_1 =	0.13004	0.009577
b_2 =	-0.004545	0.0005477 ,

rather different.

GENCAT was run on the same data and model, giving the following result.

	Coefficient	Standard error
b_0 =	-0.017649	0.009167
b_1 =	0.14853	0.003629
b_2 =	-0.00588	0.000285,

With an analogue of R^2 given by $R^{*2} = \frac{\text{Chi-squared (for } \beta_1 \text{ and } \beta_2)}{\text{Chi-squared(for } \beta_1 \text{ and } \beta_2) + \text{Chi-squared for error}}$

R^{*2} = 0.99706. The chi-squared for error is the same as the sum of squares for error obtained from MIDAS.

Notice that the coefficients are identical but that the standard errors are different. This is because the GENCAT program uses $(\underline{X}^1 \underline{V}^{-1} \underline{X})^{-1}$ as the estimated covariance matrix of the parameter estimates - assuming that K has been made equal to one. MIDAS, on the other hand uses

$\hat{\sigma}^2 (\underline{X}^1 \underline{V}^{-1} \underline{X})^{-1}$ as the estimated covariance matrix of the parameters. The mean square for error (chi-squared for error divided by its degrees of freedom) is used as the estimate of σ^2. Thus, if the chi-squared for error is less than its degrees of freedom, MIDAS will report smaller standard errors. In the more frequent case, as here, the chi-squared for error will be greater than its degrees of freedom and MIDAS will report larger standard errors.

It should be noted that in order for tests of contrasts among the parameters (in GENCAT) to be valid, the model must fit. Operationally, this is judged by the chi-squared for error being non-significant. Thus the chi-squared for error should not be significantly greater than its degrees of freedom or the model would be invalid. However, this can still result in differences in standard error estimates of 20% or more.

Which method should be used is an open question. If the values of P_i were known, the GENCAT version would be appropriate. However, it is not known what value of the chi-squared for error would invalidate the estimates. Since the covariance matrix is estimated from the data, the

(generally larger) standard errors estimated through the MIDAS method may be better. A conservative view would be to take whichever standard error was the larger as the estimate for the standard error, so long as the chi-squared for error is non-significant.

If the chi-squared for error is significant, this indicates that there is some lack of fit in the model. The model may still explain a large proportion of the variability in the data, but because perhaps of very large sample sized, the lack of fit is still real. In one sense, there is always lack of fit since no simplified mathematical model can be expected to fit a complex phenomenon perfectly. In this sense, the lack-of-fit statistic only measures whether the sample size was large enough to detect the inadequacy of the model. However, if the model explains a large proportion of the variability in the data but still has significant lack of fit, one is faced with the dilemma that the model may be quite useful even though it is a simplification.

One approach which may be considered if the model appears to be useful in spite of some lack of fit is one suggested by Finney for biological assay problems. This consists of multiplying all of the estimated variances by a "heterogeneity factor". This is equivalent to using the variances and/or standard errors as reported by MIDAS or the usual regression program. In addition, instead of using the chi-squared statistics to assess whether given parameters or sets of parameters are significantly different from zero or from each other, an "F" statistic is used. This is constructed by dividing the chi-squared statistic by its degree of freedom, and then by the error mean square. The result is then compared to a table of the "F" distribution rather than the chi-squared distribution. As an example, the chi-squared

statistic for testing whether b_0 is significantly different from zero is $X^2 = 3.71$ with 1 degree of freedom. The upper 5% point of a chi-squared table with 1 degree of freedom is 3.84, so there is some evidence that b_0 is different from zero, but not very strong evidence. On the other hand, the corresponding F statistic--which would be more appropriate were the lack of fit significant--is $f = 3.05$, with 1 and 13 degrees of freedom. The 5% critical value from an F table is 4.67, indicating that there is no evidence that b_0 is different from zero.