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A COMPARISON OF THE MICHIGAN CHECKLANE AND PERIODIC MOTOR VEHICLE INSPECTIONS†

JAIRUS D. FLORA, JR.
Department of Biostatistics and Highway Safety Institute, University of Michigan, Ann Arbor, MI 48109, U.S.A.

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Abstract—A two-year study evaluated the Michigan checklane motor vehicle inspection system as a trial substitute for a periodic motor vehicle inspection program. Two counties served as test areas. One county had a checklane inspection of 15% of its cars per year; the other county had a simulated periodic motor vehicle inspection. 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 in each group. The rates of mechanical outages were found to depend strongly on the age of the cars. Cars involved in the simulated PMVI had to have the same owner over a two year period and proved to be a self-selected group. The PMVI vehicles were in somewhat better mechanical condition than the general population even before being subject to the PMVI. After adjusting for this and the age of the vehicle, no significant differences were found in the rates of vehicles passing the inspection, even though the design had a power of at least 90% of detecting a difference of 0.05 in the rate of passing the inspection. Estimates of repair for several components were also developed and are presented.

INTRODUCTION

Most states in the U.S. employ *periodic motor vehicle inspections* (*PMVI*) under which all vehicles are inspected and certified as safe, usually annually[Grillo, 1975]. 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 to have mechanical defects (or whose registration, driver's license, or insurance is not in order). The State Police have been inspecting approximately 6% of the registered passenger cars in Michigan annually, somewhat more than 300,000 vehicles.

A number of studies have investigated the role of vehicle defects in accidents[Cotton, 1968; Little, 1968; Indiana University, 1973, 1976, among others]. In addition, a number of investigators have estimated the cost-effectiveness of various inspection programs, with mixed results[Barrett, 1972; Michigan State Police, 1972; NHTSA, 1975; MacCleary, 1971]. Flora, Truax, Tholen *et al.*[1977] present a bibliography of motor vehicle inspection literature with brief annotations. In general, less than 6% of accidents are estimated to involve vehicles with mechanical defects[Indiana University, 1973 and 1976], and only about 1.5% of accidents in Michigan involve police-reported defective equipment[Michigan Traffic Accident Facts, 1976]. Thus, there remains considerable question as to the effectiveness of vehicle inspections in accident reduction.

The present study addressed two primary questions: (1) Would a *PMVI* improve the condition of vehicles on the road in Michigan significantly? and (2) Would an increase in the rate of *checklane* inspections to about 15% of the vehicles improve the condition of the vehicles? Also, the comparison of these two different inspection procedures was of interest. Previous studies by Creswell[1974] had found a small but significant improvement in the mechanical condition of some components with a higher (20% of the vehicles) checklane inspection rate.

DESIGN

Two years were needed to conduct the project: the first year to implement the programs and the second year to measure the effects. Baseline descriptions of the vehicle populations were obtained early in the first year, then the program was implemented, and in the second year a random checklane was used to determine the state of the vehicle population after one year of the program.

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Two similar counties in Michigan, Monroe and Jackson Counties, 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 (statewide) during previous years. Monroe County was selected for the more intense 15% checklane inspection during 1975. Before implementing the operational checklane a special random checklane was operated to obtain a sample of about 2000 vehicles used to establish the condition of vehicles in Monroe County corresponding to a 5% operational checklane. After the random checklane in 1975, the operational checklane continued at a level designed to inspect about 15% of the registered vehicles. Then in 1976 a second random checklane was used to sample the population of vehicles after one year's experience with the higher (15%) level of checklane activity.

Due to legislative limitations, it was not possible to have an actual periodic motor vehicle inspection program operate. Consequently, the design aimed to simulate a PMVI as closely as possible within the framework of the enabling legislation. Jackson County was used for this group. In Jackson County, a random sample of approximately 10,000 vehicles was inspected by random checklane inspection teams during 1975. As in Monroe, this comprised approximately 15% of the registered vehicles. Vehicles inspected in Jackson County had a sticker placed on their windshields so that they could be identified in the subsequent year. The owners were required to correct any defects found and were told that they were not subject to the operational checklane inspections for a year, but that their vehicles would be re-inspected next year. The group that was re-inspected in 1976 would thus form a pseudo-PMVI sample.

In 1976 a second sample of about 2000 vehicles was taken from Monroe County to measure the effect of a 15% operational checklane. In Jackson County, a random sample of about 2000 vehicles was sought from the previously inspected population to form a pseudo-PMVI group. In order to obtain this sample, random checklanes were operated, inspecting all of the cars with stickers (indicating an inspection the previous year) and taking a sample of the rest. The result was a sample of about 2000 (actually slightly more than 2500) vehicles for the pseudo-PMVI, and about 7000 vehicles not previously inspected.

A minimum sample size of about 2000 was intended for each comparison group. This size was arrived at as follows: The overall rate of failure of the inspection was assumed to be about 50% of the vehicles inspected. This is in line with rates reported by Coverdale and Colpitts [1967], McCutcheon and Sherman [1968] and the Michigan State Police [1974]. A test of the hypothesis of no difference in the proportion failing the inspection between two sample groups was to be done at the 5% level. The sample size was chosen to give power of 90% against the alternative that the difference in proportions was 0.05 (e.g. 50 vs 45%). The sample size required for this is 2174 in each group, as found in Table A3, Fleiss [1973], or as can be easily calculated. Since operationally, once a random checklane is set up, it should be operated for at least half a day to be efficient, the actual sample sizes varied somewhat. Figure 1 summarizes the study design. Within each box the target sample size is given together with the actual number of vehicles from which data were obtained and used. Also presented in Fig. 1 with each group is an age-adjusted rate of failing the inspection. This rate was adjusted for the age of the vehicle, using the direct method. The standard population used was the registered vehicles for the state of Michigan, 1976. The "R" denotes random checklanes operated to measure the condition of the vehicle population. The "O" denotes operational checklanes operated by the State Police and from which no data were obtained.

The sample checklane inspections were conducted in cooperation between the Michigan State Police and researchers from the Highway Safety Research Institute (HSRI) of the University of Michigan. The Michigan State Police performed most of the inspection, while the HSRI personnel were involved in driver interviews, wheel pull inspections (which were only performed the first year), and supervision of the sampling procedures. Results of a special study comparing the wheel pull inspection of brakes and the moving stopping test were reported earlier by Corn, Landis and Flora [1977]. This study found that the results of a wheel pull inspection and the moving stopping test were highly correlated. The moving test was found to do somewhat better at identifying cars with inadequate brakes. Since it was more sensitive and easier to implement—it does not require equipment or personnel to effect the wheel disassembly and re-assembly—it was used as the primary test of brakes in the inspections. Static pedal pressure tests and emergency brake holding capability were also tested.

The checklane inspection took place adjacent to a roadway. Vehicles were directed out of

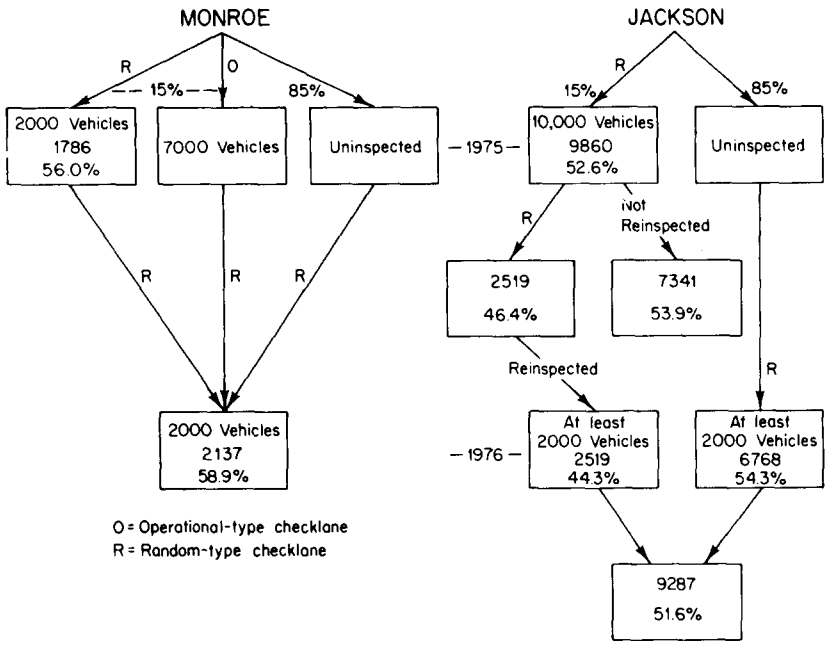

Fig. 1. Program design showing actual sample sizes and adjusted failure rates.

the traffic stream, inspected for defects in major systems, given a moving stopping test and then released, given a postcard to return certifying repair of minor defects, or given a summons for major defects. Subsamples were selected for driver interviews and for the wheel pull inspection.

A point man was responsible for selecting the vehicles from the traffic stream for the inspection. In the random checklane, each period began with a random start, after which every nth eligible vehicle was selected for the inspection. (Eligible vehicles were passenger cars and light trucks with Michigan license plates.) Thus, the random checklane used a systematic sample with a random start. The interval, n, varied, depending on 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. A randomized rotating plan was used over the eligible sites in both counties to approximately balance the high density and low density sites. The complete schedule can be found in Flora *et al.*[1977].

The operational checklane operated somewhat differently. It was not restricted to a set rotation among sites and had a somewhat wider latitude of sites. In addition, the officers used their judgment in selecting vehicles from the traffic stream for inspection. Thus, they tended to select older vehicles, vehicles with obvious mechanical problems, or vehicles suspected of defects because of the exterior appearance. The point man in the operational checklane conducted a brief visual inspection preliminary to deciding whether to require the vehicle to undergo the full checklane procedure. This is somewhat more efficient at identifying cars with mechanical deficiencies, since only about 30% of the vehicles so selected pass the inspection, while about 50% of those inspected in a random checklane were found to pass.

After a vehicle was selected for inspection, it was directed into the inspection lane. It was then inspected for operation of its mechanical components—lights, tires, brakes, exhaust, etc. All defective equipment was noted and the driver was instructed to have repairs made and to return a signed postcard so certifying. If a serious defect that was an imminent hazard was present, a summons was issued and the vehicle was towed for repairs. In addition, the operator's license, vehicle registration, and insurance were inspected to ensure that all were in order.

ANALYSIS AND RESULTS

Table 1 presents the percent of vehicles failing the inspection for any reason separately for each age of the vehicle and for six groups of vehicles. The six groups are the reinspected

Table 1. Total vehicle percent failure rates

Vehicle Age	Reinspected Vehicles Jackson County 1975 Per cent	n	1976 Per cent	n	Newly Inspected Vehicles Jackson County 1975 Per cent	n	1976 Per cent	n	Monroe County 1975 Per cent	n	1976 Per cent
1	9.3	339	0.0	14	11.3	1060	7.5	574	8.7	150	7.9
2	22.0	427	15.7	339	25.0	1450	21.3	578	24.8	315	19.5
3	29.7	467	32.7	427	37.0	1598	35.9	753	40.1	292	44.1
4	42.0	345	36.8	467	48.0	1388	47.8	890	50.4	232	54.5
5	49.2	264	51.7	345	58.1	930	58.8	758	59.5	168	69.7
6	53.4	190	52.4	264	62.4	772	65.7	625	66.7	159	77.0
7	64.5	165	64.2	190	71.7	815	76.1	580	79.2	154	82.5
8	60.4	118	63.9	165	78.9	611	85.4	605	85.1	101	86.9
9	78.7	78	69.8	118	84.0	457	85.1	496	85.9	78	85.4
10	75.0	42	76.0	78	89.1	320	86.5	352	84.0	50	87.1
11	78.8	35	81.8	42	89.3	215	93.8	225	94.6	37	91.7
12	77.8	18	72.7	35	88.9	117	91.0	164	80.0	20	89.8
13	71.4	6	88.9	18	89.2	37	93.4	75	85.7	14	100.0
14	100.0	4	57.1	6	87.5	32	83.9	32	100.0	8	88.2
15	100.0	1	100.0	4	100.0	10	91.7	23	100.0	2	100.0
16	100.0	3	100.0	1	100.0	8	91.7	12	100.0	1	100.0
17+	100.0	3	66.7	6	72.2	13	80.8	26	100.0	5	100.0
Overall	38.5	2505	45.2	2519	49.6	9860	57.9	6768	51.9	1786	62.0
Standardized Rate	46.4		44.3		53.9		54.3		56.0		58.9
Standard Error	0.98		0.86		0.44		0.52		1.00		0.88

vehicles from Jackson County in 1975 and in 1976, and the sample of non-reinspected cars i Jackson County in 1975 and in 1976, and the sample from Monroe County in 1975 and in 1976 Also presented is the crude percentage of cars failing in each group and the standardized failur rate with its standard error. It also presents the number of vehicles in the same groups upo which these percentages were based. The most evident feature of these data is the tendency fo the failure rates to increase with the age of the vehicle.

The data from Monroe County provided a comparison of the checklane inspection progran at the 5 and 15% levels. The rate of passing the inspection was found to depend strongly on th age of the car, with older cars much more likely to fail the inspection. This dependence can b approximately described by a quadratic polynomial in the age as in Flora, Copp an Tholen[1980]. The distribution of cars by age in the samples from Monroe County differed– cars inspected in 1976 averaged 0.9 yr older than those inspected in 1975. Consequently, a adjustment for age must be made to remove the effect of the differing ages before comparin the effects of the different inspection levels.

The direct method of adjustment was used to standardize the rate of failing the inspection t the age distribution of all registered passenger cars in Michigan in 1976. The resultin age-adjusted rates and their estimated standard errors were for Monroe County:

	1975	1976
Rate:	56.0%	58.9%
Standard error:	1.01%	0.88%

Clearly the difference in the adjusted rates of failing the inspection is of little practica importance, although the difference is marginally statistically significant ($P = 0.03$). Wha difference there is would indicate a worsening of the vehicles condition with the highe inspection rate, the opposite of what is desired and expected.

Figure 2 presents the observed rates, together with a fitted quadratic in age for each year' data. The curves were fit by the method of weighted least squares. A method for performing th calculations using standard regression programs was presented in Flora, Copp an Tholen[1980], where the conclusion was reached that a quadratic polynomial in age fit the dat adequately. A more detailed discussion of the method of weighted least squares or modifie minimum chi-square for categorical data may be found in Grizzle, Starmer and Koch[1969 while a general computer program for the computations is given in Landis, Stanish, Freema and Koch[1976].

The parameters of the fitted regressions are given in Table 2. An overall test of th hypothesis that the two regressions are the same (that the vectors of parameters are equal) gav a chi-squared statistic of 6.68 with 3 degrees of freedom ($0.05 < P < 0.10$), not significant at th

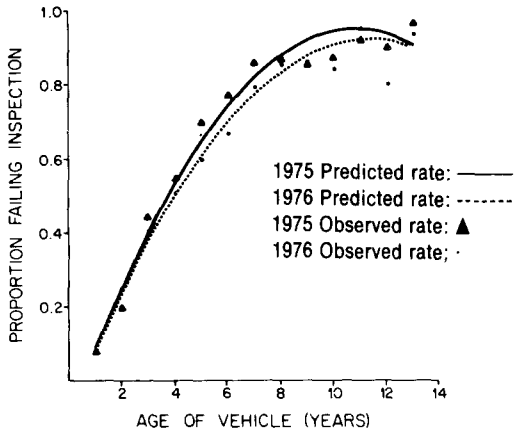

Fig. 2. Observed and predicted failure rates by age for Monroe County samples.

5% level. Individual tests of the equality of corresponding parameters (intercepts, linear coefficients, and quadratic coefficients) all gave chi-squared statistics less than one, each with one degree of freedom. The conclusion is that there is no significant difference in the rates of failing the inspection after adjusting for the age of the vehicle. What difference was observed was in the direction of a worse mechanical condition of cars after being subject to the higher rate of checklane inspections. Thus, increasing the checklane inspection program from a rate of 5% of the cars to 15% of the cars had no appreciable effect on the mechanical condition of the vehicles. The extra expenditure of resources to attain the higher inspection rate apparently would not result in any important improvement in the condition of the vehicles on the road and so would not appear to be cost-effective.

Although it is generally quite difficult to show that two groups have equal rates of passing an inspection, the conclusion that the two groups do not differ in their rates of passing the inspection by enough to be of practical importance seems warranted here. The study was planned to give 90% power against a difference in the passing rates of 0.05 (5%), if the standard error of each rate was 0.012. Although adjusted rates were used, their estimated standard errors were both less than assumed in the design (0.0101 and 0.0088). Thus, there is less than a 10% chance of observing such a small difference as was observed if the true population rates of passing the inspection actually differed by 0.05 or more.

There were 9860 vehicles inspected in Jackson County in 1975. Of these, the random checklanes in 1976 identified 2519. These vehicles were re-inspected in 1976 and form the pseudo-PMVI group. The percent of these vehicles failing the inspection is presented by age and year of inspection under the heading "Reinspected Vehicles" in Table 1. The rates increase with the age of the vehicle. The crude rate for the re-inspected vehicles is higher in 1976 than it

Table 2. Estimated regression parameters Monroe county

	1975		1976	
	parameter	standard error	parameter	standard error
Intercept	-0.070	0.026	-0.100	0.014
Linear	0.173	0.010	0.194	0.008
Quadratic	-0.00753	0.0008	-0.00897	0.00058
Lack of fit χ^2		6.55 (10 df)		29.35 (10 df)
	combined			
Intercept	-0.089	0.017		
Linear	0.186	0.0063		
Quadratic	-0.0084	0.00046		
Lack of fit		35.40 (20 df)		

was in 1975, but these vehicles were then approximately one year older. The adjusted rates are also given in Table 1, and these were lower.

Standardizing the rates for the age of the vehicle by the direct method as before gave the following rates and estimated standard errors for the re-inspected vehicles—the pseudo-PMVI group:

	1975	1976
Rate:	46.4%	44.3%
Standard error:	0.98%	0.86%

A slight improvement has occurred. The proportion failing the inspection has been reduced from 46.4 to 44.3%. However, this reduction is not statistically significant ($P = 0.1074$).

The relationship of failure rates to age was again described by a quadratic polynomial in age. The curves were fit by weighted least squares. Figure 3 presents the fitted curves and the observed values for the two years' data. The two curves can be seen to be quite similar, with that for 1976 slightly lower than that for 1975. The estimated parameters for the two curves are given in Table 3. The overall test that the two curves were the same was not significant at the 10% level ($\chi^2 = 5.24$, 3 d.f., $0.1 < P < 0.25$). Further, the tests of equality of the individual coefficients were also all non-significant, giving a chi-squared statistic of less than one with one degree of freedom in each case. Thus, the conclusion was that the two groups did not differ significantly in the rate of failure of the inspection.

In 1975 this group of vehicles had been subjected to a checklane inspection. In 1976, these vehicles represented a population with one year's experience with a (simulated) annual PMVI. The unadjusted rate of failing the inspection was worse after one year's PMVI experience, but the vehicles were older. After adjusting for the age of the vehicles, the PMVI showed a slight, but non-significant improvement. Thus, the PMVI—as simulated in this experiment—did not result in a significant improvement in the mechanical condition of the vehicles.

Since the PMVI group was of particular interest, attempts were made to estimate the repair rates effected by the PMVI program. In 1975, a total of 6200 drivers were issued postcards to return certifying that a mechanical deficiency had been corrected. Of these, 3700 or 59.7% were returned. A random sample of 400 vehicles for which postcards were issued was drawn for further follow up. Of the 400, 204 postcards were returned. Table 5 gives the postcard return rate estimated from this sample by the total number of defects of the vehicle. The return rates decreased with increasing numbers of mechanical outages, suggesting that repair rates may have been less for vehicles with several components out of order. It should be noted that drivers of vehicles with imminent safety hazards were issued summonses—not postcards. This comprised 1.3% of all vehicles. These vehicles with severe safety hazards were thus repaired—or turned over to the courts for prosecution.

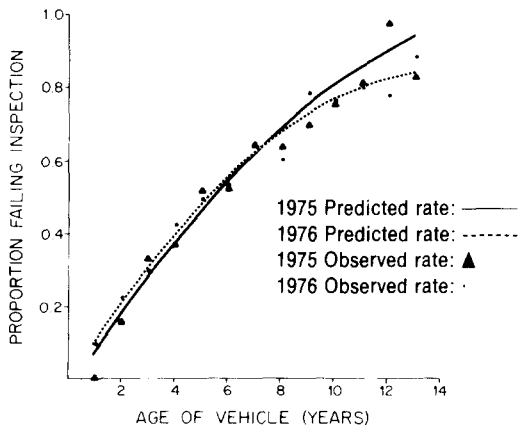

Fig. 3. Observed and predicted failure rates by age for the PMVI samples.

Table 3. Estimated coefficients, reinspected vehicles

	1975		1976	
	parameter	standard error	parameter	standard error
Intercept	-0.017	0.0209	-0.040	0.0339
Linear	0.121	.0099	0.117	0.0121
Quadratic	-0.0042	.00087	-0.0032	0.00086
Lack of fit	7.05	10 df	25.97	10 df
	combined			
Intercept	-0.014	0.0173		
Linear	0.113	.00706		
Quadratic	-0.00315	0.00055		
Lack of fit	38.25	23 df		

Matching the records of the cars in the re-inspected group gives an objective estimate of the repair rates. The observed repair rates by number of defects are also presented in Table 4. These repair rates may be observed to be lower than those estimated from postcards returned. In addition, the decrease with increasing number of mechanical defects is larger than the postcards would indicate. It should be noted that only about two-thirds of the vehicles that passed in 1975 also passed in 1976, indicating that about a third of the vehicles experienced a component outage over the year that had not been corrected by the time of the re-inspection. It is possible that the repaired vehicles also experienced a similar new outage rate. If so, then the observed rates of repair are lower than the actual ones—possibly by about a third. The last column of Table 4 gives an estimated repair rate adjusting for the possible new failures during the year. For example, of vehicles with 2 defects found in the 1975 inspection, 30.2% were defect-free in the 1976 inspection and must therefore have been repaired. If a third of all repaired vehicles (that had 2 defects in 1975) suffered a new outage during the year, the proportion passing the inspection in 1976 would be lower than the proportion actually repaired. A repair rate of 44.6% with a new outage rate of one third would give the observed passing rate of 30.2%.

Table 5 gives the data on failure rates during the year and on repair rates by component. With few exceptions, the observed repair rates are near 80%. If the new failure rate (during the 1975–76 year) is assumed to apply to the repaired cars as well, the estimated repair rates would be even larger—near 90% for most components. One exception is the license plate light, with an observed repair of only 59%. It seems likely that many drivers did not consider it important enough to fix. Another exception was (noisy) exhaust. There may have been some reluctance to effect an expensive repair to replace a muffler that was failed for excessive noise.

The rate at which new outages occurred during the year also varied with component, but was generally in the range from about 4 to 10%. For example, these data estimate that 4.3% of the vehicles had a brake light go out over the year, while 10.1% needed windshield washer or wiper repairs. Although the repair rates were fairly high, the pseudo-PMVI program did not result in a significant improvement in the proportion of vehicles passing the inspection.

Table 4. 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
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%

Table 5. 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]	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

Direct comparisons of the checklane program with the PMVI program proved to be inappropriate for two reasons. First, there was a difference in the proportion of cars passing the inspection by county. Jackson County had a passing rate 3.4 percentage points higher than Monroe County in 1975 (47.4% compared to 44.0%). Second, and more importantly, the subgroup of vehicles that were re-inspected in Jackson County proved to be a self-selected group in generally better mechanical condition than the general population of vehicles in Jackson County in 1975. In 1975 the cars that were subsequently re-inspected had a standardized passing rate of 53.6%, compared to the rate of 46.1% for those cars that were not subsequently re-inspected. This selection was unexpected and discovered only after the completion of the project. The reasons for this selection bias are not known. It may be that some drivers of vehicles that did not pass the inspection in 1975 were successful in avoiding the random checklanes the next year. On the other hand, there may be a tendency for cars with many mechanical problems to be sold or traded, eliminating them from the population that could be identified as re-inspected. Such factors as these may have operated to result in those cars more likely to be re-inspected being those in somewhat better mechanical condition.

Failure rates by group, component, and age are presented in Tables 6–10. Table 6 presents the failure rates for washers and wipers. The rates for each age of car are presented, together with the overall (crude) rate. The last entries are the age-adjusted rate and its estimated standard error. After standardizing for the age distribution, only slight differences remain. Often, failure was merely for lack of fluid in the washer, so the importance of this component is somewhat open to question.

Table 6. 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
Standardized Rate	16.1	11.9	20.0	18.5	25.2	23.1
Standard Error	0.86	0.65	0.41	0.43	1.02	0.85

Table 7. 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	37.5
Standardized Rate	7.3	6.6	12.3	11.6	15.0	14.4
Standard Error	0.65	0.51	0.35	0.35	0.86	0.69

Table 8. 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
Standardized Rate	8.4	8.5	10.3	11.0	8.4	11.0
Standard Error	0.66	0.58	0.33	0.36	0.70	0.64

Table 9. 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
Standardized Rate	31.4	28.2	36.0	37.3	34.5	36.5
Standard Error	1.01	0.85	0.47	0.53	1.07	0.92

Table 10. 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
Standardized Rate	9.9	14.8	13.5	17.3	13.7	21.0
Standard Error	0.72	0.71	0.37	0.43	0.84	0.82

Table 7 presents the failure rates for the brakes. These rates are for the moving stopping test and/or the static test of the brake pedal and emergency brake. A comparison of the moving stopping test and a wheel pull inspection of the brakes was presented earlier by Corn, Landis and Flora[1977], where the moving stopping test was found to be the more sensitive. Again, age-standardized rates are presented, together with their estimated standard errors. These standardized rates show slight improvements in 1976 in all groups. Coupled with the high (91%) observed repair rate for brakes, this suggests that the inspection programs may have improved the condition of the brakes slightly.

Table 8 gives the failure rates for headlights, and Table 9 the failure rates for all lights. Generally only slight differences are noted from 1975 to 1976 in the adjusted rates. Headlight outages (about 10%) were about a third of light outages (about 30%) after standardizing for age.

Table 10 presents the failure rates for tires. Virtually all of these were for insufficient tread, although tires were also inspected for bulges, cracks, or other defects. Every group showed a significantly higher failure rate for insufficient tire tread in 1976 than in 1975, even after adjusting for the different age distribution of the vehicles inspected in the two different years. The reasons for this are uncertain. There was a national rubber manufacturers strike during the spring and early summer of 1976. This may have led to a perceived shortage of tires or may have led some drivers to postone replacing tires longer than they would have normally. Another and probably more important factor was the inspection method. In 1975, tires were inspected visually for wear bar indicators. In 1976, tire pressures were measured on most vehicles and the tread depth was measured with a gauge. (Tread was insufficient if two adjacent grooves measured less than 2/32 inch.) The inspection may well have been more stringent in 1976, resulting in the higher failure rates. While most components showed no change or slight improvement in 1976, tires were markedly worse. This led to the total vehicle failure rate being somewhat worse in 1976 than in 1975.

Probably at least some of the difference in tire failure rates is real, although some seems likely to be related to the measurement. If we assume that the tire failure rates should have been the same in 1976 as they were in 1975, then the effect would be to reduce the adjusted failure rates for the total vehicle. Since some vehicles that failed for tires also failed for other reasons, this reduction would tend to be less than would be found by reducing the adjusted failure rates by the difference in tire failure rates. However, decreasing the total vehicle adjusted failure rates in 1976 by the amount of increase in tire failure rates would appear to provide an upper bound for the effect of different inspection of tires. If this is done, the modified adjusted failure rates become 39.4, 50.5 and 51.6% for the reinspected cars in Jackson County, the newly inspected cars in Jackson County, and the cars in Monroe County, respectively. This would result in small, but statistically significant (at the 5% level) reductions in the failure rates in all three groups. Even so, differences among the groups would not be

statistically significant, except for the difference between the reduction for the reinspected and newly inspected cars in Jackson County, which is of marginal significance. Given the speculative nature of the assumptions, it would appear best to conclude that no significant differences in the reductions among the three groups were found.

Table 11 presents a comparison of the failure rates by component for all vehicles inspected in the random checklanes in 1975 to the vehicles inspected in the operational checklanes statewide. The operational checklanes data are from the Michigan Traffic Accident Facts[1975]. The failure rates in the operational checklanes are generally considerably higher than those found in the random checklanes. This points out the efficiency of the operational checklane at identifying vehicles with some defective equipment from the visual inspection by the point man.

It is worth noting that the condition of vehicles was found to be highly dependent on the age of the vehicle. Throughout, an adjustment for vehicle age has been used before making other comparisons. The mileage of the vehicle is an alternative variable for adjustment. In the present study, the mileage was found to be somewhat more associated with the vehicle's condition than the age. However, the two are very closely correlated. Age has been used, because it is an easier variable to determine. A possible inspection strategy would be to require inspections at a certain age of the vehicles. This could be administered fairly well. Although mileage might be a slightly better variable, it would be administratively much more difficult. For these reasons, age rather than mileage has been used for adjustment.

The results from the random checklane inspections in Michigan in 1975 and 1976 generally fell in the ranges quoted in the report "Data on Vehicle Inspection Programs for State Appointed Stations, State Owned and Operated Stations,"[1976]. The components for which the Michigan data disagreed with those published data were tires, steering, and headlights. For tires, Michigan failure rates ranged from 14.4 to 19.7%, while the American Association of Motor Vehicle Administrators (AAMVA) range was from 0.4 to 7.2%. For steering, Michigan results ranged from 0.2 to 0.4%, while the AAMVA range was from 1.5 to 9.1% failures. For headlights, Michigan vehicles ranged from 8.4 to 11.8% failures, while the ranges reported by the AAMVA were from 13.9 to 42%. The reasons for the differences are unclear. The age distribution of the vehicles could be a factor. The stringency and exact details of the inspection are probably more important. For example, the AAMVA checks headlight aim mechanically—the allowable error varies by state—while the Michigan checklane inspects headlight aim visually. A vehicle in Michigan would fail headlight aim only if grossly misaligned, as for instance, the result of a crash.

The groups of newly inspected vehicles in Jackson County in 1975 (after removal of the vehicles in the reinspection group) and in 1976 represent a group of vehicles not influenced directly by the inspection program. That is, none of these vehicles was inspected and required to correct any defects the previous year. As a result, any effect on these vehicles that any of the programs had would be only a spill-over effect. That is, owners may keep a vehicle in good condition because it might be inspected—this is the rationale of the checklane inspection. This group represents the condition of vehicles only affected by the publicity of inspections, not actual inspections. As such, they do not reflect the actual experience of a checklane inspection,

Table 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

since the 5, 15%, or whatever of vehicles that are actually inspected and repaired are excluded. The rates of passing the inspection of this group were generally comparable with the checklane inspection group in Monroe County.

DISCUSSION

In this experiment, neither increasing the level of inspection in a checklane program from 5 to 15% nor introduction of a PMVI program resulted in an improvement of the general vehicle population's mechanical condition as judged by the passing of a vehicle inspection. After adjusting for the age of the vehicle, the population subjected to a 15% checklane inspection rate showed a slightly lower rate of passing the inspection than did a population subject to a checklane inspection at the rate of 5% of the vehicles per year. On the other hand, the PMVI group showed a slight improvement. Neither change was statistically significant, and both were too small to be of much practical importance.

The PMVI used here was only an approximation of an actual PMVI. Drivers knew that there was a good chance that their cars would be re-inspected the following year, but also knew that they might be able to avoid the inspection. They did not know when they would be re-inspected in contradistinction to an operational PMVI inspection program. The random re-inspection the second year in the PMVI group may be more representative of the general condition of PMVI vehicles than rates observed at a fixed time of inspection, since drivers could check to ensure that their vehicles were defect-free at the time of the scheduled inspection, while not improving the condition at other times. On the other hand, this would result in the vehicles being fixed at a specific time each year, in anticipation of the scheduled inspection. The same result might be anticipated from the simulated inspection, since drivers were supposed to correct any mechanical problems with their cars at the time of the inspection. The repair rates indicated that compliance in the simulation was generally 80% or higher even though the experimental program did not have the power to enforce re-inspections until the defects were all corrected.

The sampling method used by the random checklanes may not result in all vehicles being sampled with equal probability. The site requirements specified that a fairly high traffic trunkline road be used. No interstate highways or freeways could be used. In addition, low density rural and/or residential roads could not be used. As a consequence, cars operated primarily on long trips on interstates could have been underrepresented. Likewise, cars operated exclusively in rural areas with little traffic situations would be included. The samples obtained differed from the population of registered vehicles in age and also in manufacturer. However, the population of vehicles may not be used in the same proportion as they are registered. The sample was intended to represent the population of cars in local, frequent use.

Two alternative inspection programs were compared with an existing checklane inspection program. The first was more intense checklane inspection program, inspecting 15% of the registered vehicles per year rather than the previous 5%, and the second was a pseudo-PMVI program intended to mimic a PMVI as closely as possible under the existing legislative restrictions. After adjustment for the age of the cars inspected, the more intense checklane program showed a slightly higher rate of failing the inspection, but no statistically significant difference from the previous program. After adjustment for the age of cars, the simulated PMVI program showed a small reduction in the proportion of cars failing the inspection, but again, the improvement was not statistically significant.

As a consequence, the study results would not suggest that a change to either a more intense checklane inspection or to a PMVI is likely to markedly improve the rate of passing the inspection. It should be remembered that the changes were measured relative to an existing checklane inspection program. Also, the study only used a simulated PMVI. It is possible that an actual perodic vehicle inspection might be more effective than the simulated one was in improving vehicle condition as measured by the proportion of vehicles passing the inspection.

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