Consumer Costs of Unnecessary Automobile Repairs

Bernard J. Schroer and William F. Peyton, Kenneth E. Johnson
Environmental and Energy Center, University of Alabama in Huntsville

Automotive repair is the subject of much consumer, as well as congressional, debate. This paper summarizes the results of a three-year automotive diagnostic inspection program aimed at collecting and analyzing automotive repair costs, especially unnecessary repair costs.

The excessive costs of owning, maintaining, and repairing automobiles have become increasingly burdensome. These costs have generated widespread consumer discontent and concern about the automobile, its costs and repairability. Except for the initial purchase of a car, the cost of almost every maintenance and repair item, as well as the cost of operation associated with the automobile, has risen significantly faster than the overall cost of living.

These excessive costs have resulted in much criticism of the repair industry. Beginning in 1968, the U.S. Senate Subcommittee on Antitrust and Monopoly began a 4-year investigation of the automobile repair industry. These hearings disclosed major areas where multibillion-dollar economic losses occur to the motorists. Foremost was the cost of unnecessary and unsatisfactory repairs. Other areas included the enormous damage suffered by vehicles in very low speed crashes, used cars that had the odometers turned back to enhance their value, and the economic losses resulting from stolen vehicles.

These factors served as the justification for the passage of the Motor Vehicle Information and Cost Savings Act of 1972 (PL 92-513). Title III of this act authorized the U.S. Secretary of Transportation to establish a number of motor vehicle diagnostic inspection and test centers throughout the country. The objective of the program was to provide for the accumulation of data to determine if diagnostic inspections are cost effective, i.e., do public benefits exceed program costs. Specific types of data collected by the inspection centers included vehicle outages, exhaust emission rates, repair costs, facility operation and staffing requirements, vehicle-in-use standards and feasible reject levels, equipment reliability and interchangeability, and the capability of the repair industry to correct diagnosed deficiencies.

This paper discusses one of the five motor diagnostic inspection demonstration programs. Specifically, this paper addressed the results of the analysis of the vehicle repair cost data from the Alabama motor vehicle diagnostic inspection demonstration project. Emphasis is placed on the unnecessary repairs by major vehicle system, by type of repair facility, and by selected vehicle components (1, 2).

DESCRIPTION OF AUTO CHECK

The Alabama motor vehicle diagnostic inspection demonstration project (3), known locally as Auto Check, was established by the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) in the fall of 1974. Auto Check is conducted by the University of Alabama in Huntsville, Office of Highway and Traffic Safety.

Auto Check has been designed as a model automotive diagnostic inspection facility. The exterior of the facility is shown in Figure 1, and a corresponding layout of the facility is shown in Figure 2. The facility covers over 1288 m^2 (14 000 ft^2) including administrative offices, a reception area, and a 30-seat theater. The facility can inspect 228 vehicles in an 8-h shift.

The inspection area consists of three parallel lanes 34 m (110 ft) long. Each lane contains five inspection stations. A description of the equipment in each lane is given in the following table:

Station	Equipment	Manufacturer	Model
1	Exhaust gas analyzer	Chrysler	Model 1
	Chassis dynamometer	Clayton	1492 watts (200 hp)
2	Dynamic wheel alignment system	Hunter	F-60
3	Headlight tester	Hunter	HD
4	Dynamic brake analyzer	Clayton	DB-8-CP
5	Twin post lifts	Dover	WABU-28-H
	Twin post lifts	Hunter	DA 76 cm (30 in)

In addition to the five stations, there are also two engine diagnostic bays each containing a Clayton CSS/7100 Engine Analyzer.

An inspection consists of checking 106 items on a vehicle. These items include tires, glass and body, interior, under hood, engine emissions, wheel alignment, headlight alignment, all lights and turn signals, brakes, wheels, fuel system, exhaust system, steering, and suspension.

Auto Check began inspecting cars early in 1975. The initial NHTSA guideline limited inspection to only the more popular vehicles in the 1968-1973 model years. The only foreign cars inspected were Volkswagens, Toyotas, and Datsuns. Since June 1976, Auto Check has been inspecting all model years, including pickup trucks and vans.

Auto Check has conducted over 30 000 inspections on 19 000 vehicles. Over 22 percent of the vehicles have returned for a follow-up or repair inspection after the defective items had been repaired. Many cars have returned for second, third, fourth, and even fifth periodic inspections at 6-month intervals.

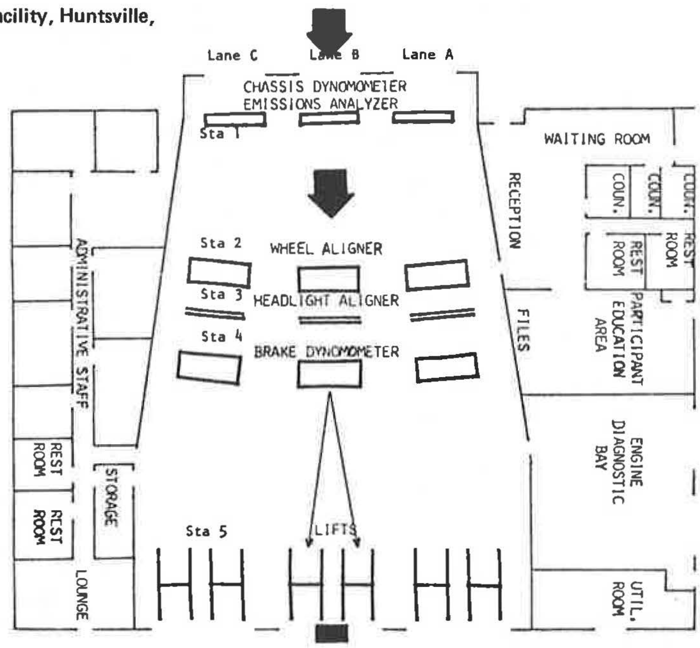
During the first two years of the program, the motorists were divided into two groups. One group, the experimental group, received detailed diagnostic inspection results. The other group, the control group, received only generalized inspection results typical of a state vehicle inspection. After the vehicles were repaired, they were again inspected to determine if the repairs were satisfactory. At that time, repair cost data and fuel and maintenance data were obtained from the motorists.

SELECTION OF SAMPLE

The sample for this study consisted of only those 1968-1973 model-year vehicles that had a brake, engine, alignment, steering, or suspension repair. The peri-

Figure 1. Exterior view of Auto Check facility, Huntsville, Alabama.

Figure 2. Interior layout of Auto Check facility, Huntsville, Alabama.



odic inspection results along with the repair costs for these vehicles were then entered into the university's computer.

The repair costs were analyzed relative to the 106 items on the Auto Check Inspection Form by a team of two individuals: an experienced garage shop supervisor and an experienced automotive parts specialist. Both of these individuals reviewed each form. In those instances where the two could not agree, an automotive engineer was consulted.

The following data elements were entered into the computer for each repair item or repair action:

1. Repair item—value of 1-106 corresponding to the inspection items;
2. Repair classification—required, recommended, optional, or unnecessary repair;
3. Repair facility classification—car dealer, tire dealer, merchandising chain (i.e., Sears), independent garage, service (gas) station, or owner repair—determined by the facility's major source of income;
4. Repair facility name;
5. Labor costs;
6. Parts costs; and
7. Participant's sex, age, marital status, and zip code.

The repair of each item was classified as being required, recommended, optional, or unnecessary. The criteria for determining the repair classification were

1. A repair was considered required if the repaired item was found to be substandard during the Auto Check inspection (judged as failed or marginal by data on the inspection form);
2. A repair was considered recommended if the repaired item is normally repaired as part of the repair of another substandard item, even though nothing was found to be substandard with the subject item during the Auto Check inspection, i.e., a wheel alignment when a worn steering system component is replaced;
3. A repair was considered optional if the repaired item could or could not be normally repaired as part of another substandard item repair, even though nothing was found to be substandard with the subject item during the Auto Check inspection, i.e., brake cylinder rebuilding when brake linings are replaced; and
4. A repair was considered unnecessary if the repaired item was found to be satisfactory during the previous periodic inspection and no other repair of any other marginal or substandard component would normally affect the decision to repair the subject item, i.e., a tuneup when only the carburetor idle mixture

ratio screw needed adjustment, or brake drum turning when only the linings were worn but the drum was not scored.

It should be noted that an unnecessary repair does not necessarily indicate that the motorist was "ripped off." Instead, it indicates that a repair action was made to an item that passed the Auto Check inspection. For example, an unnecessary repair may have been requested by the motorist for preventive maintenance. Or, in fairness to the repair facility, unnecessary repairs may have been performed to ensure compliance with the Auto Check reinspection. To ensure compliance, the industry may tend to take a conservative posture, much as a medical doctor with the fear of malpractice may over-test patients. Consequently, the repair facility may tend to over-repair not only to ensure compliance but also to ensure that the motorist does not have to return in the near future for additional repairs.

Specific criteria were developed for classifying the repairs (4). The criteria for classifying brake repairs are given in Table 1. In reading this table, it is recommended that the brake linings be repaired (replaced) when the brake drum is repaired (presumably because the drums are scored). A repair was only considered unnecessary if a prudent, knowledgeable individual, knowing the condition of that component and all the related components within the system, would not have the item repaired.

The distribution of the sample by make and model within vehicle year is given in Table 2. Of the 3140 vehicles, 10 percent were 1968 models; 14 percent, 1969; 17 percent, 1970; 19 percent, 1971; 21 percent, 1972; and 20 percent, 1973. Likewise, 46 percent were manufactured by General Motors (GM), 21 percent by Ford, 20 percent by Chrysler, 5 percent by American Motors Corporation (AMC), 4 percent by Volkswagen (VW), 3 percent by Toyota, and 2 percent by Datsun.

REPAIR COST ANALYSIS

A summary of the 6075 repair actions by each of the five major vehicle systems is given in Table 3. Of these repair actions, 65 percent were classified as required, 3 percent recommended, 7 percent optional, and 25 percent unnecessary.

A summary of the repair costs by each of the five systems is given in Table 4. A total of $129 217 in repair costs were analyzed. The unnecessary repair costs accounted for 29 percent of the repair dollar; the recommended, 3 percent; and the optional, 8 percent.

Systems Repairs

Table 5 summarizes the unnecessary repair actions and associated repair costs by vehicle system and repair facility. Overall, 30 percent of service station, 28 percent of tire dealer, 28 percent of chain, 26 percent of independent garage, 25 percent of car dealer, and 20 percent of owner repairs were unnecessary. There is no significant difference among the repair facilities, except for owner repairs, which were significantly lower ($p \cong 0.03$).

The unnecessary repair rate was significantly higher for female participants (27 percent) than for male participants (24 percent). Females also spent statistically more (38 cents) for unnecessary repairs than males (30 cents).

The unnecessary repair rate was the same (24 percent) for both the control and diagnostic groups. Also, 33 cents of every dollar the control group spent for repairs and 31 cents of every dollar the diagnostic group spent for repairs were unnecessary (not statistically significant).

The detailed statistical analyses of engine repairs indicated that chain stores had the highest rate of unnecessary repairs (40 percent); however, there is no significant difference among the repair facilities, except for owner repairs, which were significantly lower ($p \cong 0.001$).

Males performing their own engine repairs had a significantly lower unnecessary repair rate (21 percent) than those males who had their repairs made commercially (34 percent). Uninformed females in the control group spent more on unnecessary engine repairs than on legitimate repairs. However, informed females in the diagnostic group had unnecessary repair costs comparable to those for informed males.

Engine system repair costs were grouped into three categories: under $10, $10-$40, and over $40. The first category is a typical cost of an engine idle mixture ratio adjustment, the replacement of spark plugs, or a

Table 1. Classification of repairs performed on brake system components.

Failed Item	Repaired Item: Drum	Lining	Structural Parts	Brake Cylinders
Drum	Required	Recommended	Unnecessary	Unnecessary
Lining	Unnecessary	Required	Unnecessary	Optional
Structural parts	Unnecessary	Unnecessary	Required	Unnecessary
Brake cylinders	Unnecessary[a]	Unnecessary	Unnecessary	Required

[a]This repair is unnecessary unless the repaired item was contaminated by brake or axle fluid.

Table 2. Sample distribution by manufacturer, 1968-1973 models.

Manufacturer	Model Year: 1968	1969	1970	1971	1972	1973	Total/%
General Motors	169	229	266	243	282	260	1449/46.1
Ford	47	76	117	138	136	132	646/20.6
Chrysler	52	84	80	107	160	137	620/19.8
American Motors	9	23	27	17	43	45	164/5.2
Volkswagen	24	23	18	20	16	11	112/3.6
Toyota	4	7	14	25	14	22	86/2.7
Datsun	1	4	11	21	19	7	63/2.0
Total/%	306/9.7	446/14.2	533/17.0	571/18.2	670/21.3	614/19.6	3140/100

Table 3. Repair actions by vehicle system.

Vehicle System	Repair Action: Required No.	%	Recommended No.	%	Optional No.	%	Unnecessary No.	%	Repairs Total	%
Emission	894	60	10	1	130	9	445	30	1479	24
Steering	26	58	0	0	9	20	10	22	45	1
Alignment	1060	84	20	2	84	7	101	8	1265	21
Brakes	1675	60	143	5	191	7	789	28	2798	46
Suspension	277	57	5	1	35	7	171	35	488	8
Total	3932	65	178	3	449	7	1516	25	6075	100

Table 4. Total repair cost by vehicle system.

Vehicle System	Repair Classification: Required Amount ($)	%	Recommended Amount ($)	%	Optional Amount ($)	%	Unnecessary Amount ($)	%	Total ($)	%
Emission	20 518	54	175	0	3 903	10	13 155	35	37 750	29
Steering	477	60	0	0	138	17	184	23	799	1
Alignment	11 233	83	227	2	923	7	1 099	8	13 482	10
Brakes	35 398	59	3521	6	4 139	7	16 693	28	59 750	46
Suspension	9 624	55	120	1	1 186	7	6 507	37	17 436	14
Total	77 250	60	4043	3	10 289	8	37 638	29	129 217	100

Table 5. Unnecessary repair actions and costs by repair facility.

System/Repair Facility	Unnecessary Repair Actions: Number	%	Unnecessary Repair Costs: Amount ($)	Cents/$
Engine				
Service station	52	35	1671	45
Tire dealer	6	26	264	39
Car dealer	146	33	4317	44
Independent	98	32	3086	33
Chain	40	40	1081	49
Owner	27	20	441	15
Brakes				
Service station	86	32	2312	36
Tire dealer	120	38	2138	31
Car dealer	142	25	4340	32
Independent	153	28	3336	31
Chain	84	34	2254	32
Owner	44	20	455	14
Alignment				
Service station	7	12	109	17
Tire dealer	16	8	172	8
Car dealer	13	6	131	5
Independent	15	8	131	7
Chain	18	8	185	7
Owner	0	0	0	0
Suspension				
Service station	5	22	179	20
Tire dealer	23	43	962	41
Car dealer	18	29	913	38
Independent	23	32	975	33
Chain	56	40	1669	42
Owner	6	26	180	30
All				
Service station	150	30	4272	36
Tire dealer	165	28	3537	30
Car dealer	319	25	8765	34
Independent	289	26	7530	31
Chain	198	28	5186	33
Owner	77	20	1077	16

Table 6. Unnecessary repairs for selected brake components.

System/Repair Facility	Number Unnecessary Repairs	Unnecessary Repair Rate (%)	Unnecessary Repair Costs ($)	Unnecessary Repair Costs (%)
Front disc or drum				
Service station	16	62	188	56
Car dealer	29	59	414	48
Independent	37	54	402	43
Tire dealer	32	70	310	70
Chain	10	77	158	50
Individual	1	9	47	15
Front lining				
Service station	31	44	1056	49
Car dealer	48	50	1487	50
Independent	32	35	883	34
Tire dealer	19	28	631	34
Chain	25	37	667	32
Individual	5	11	68	9
Rear disc or drum				
Service station	7	37	90	21
Car dealer	19	63	178	54
Independent	28	57	240	54
Tire dealer	38	79	251	67
Chain	4	67	22	21
Individual	2	20	49	16
Rear lining				
Service station	19	28	437	24
Car dealer	19	18	515	18
Independent	25	24	612	25
Tire dealer	17	25	350	23
Chain	20	36	533	36
Individual	16	27	136	21
Rear wheel seal				
Service station	14	39	123	26
Car dealer	17	35	547	43
Independent	28	44	279	27
Tire dealer	13	46	194	46
Chain	32	67	354	57
Individual	8	62	26	38

basic timing adjustment. The second category is a typical cost of a tuneup. The third category is a typical cost of a more expensive repair such as a carburetor replacement or the grinding of exhaust valves. The results were 18 percent of the unnecessary repairs were below \$10; over 51 percent of the required repairs were in this price range. On the other hand, over 20 percent of the unnecessary repairs exceeded \$40; only 13 percent of the required repairs exceeded this amount. The data suggest that an unnecessary repair is more likely to be an expensive repair ($p < 0.001$).

The females in the uninformed group (control group) had a significantly higher percentage of unnecessary repairs in excess of \$40 compared with the male and informed female groups. This suggests that an uninformed female who has a vehicle's engine repaired is likely to have an excessive repair bill, because she is less able to interface with the repair facility from a knowledge level. On the other hand, if the female has information, suggesting that she could verify the repair shop's conclusion, she is not as likely to have an excessive repair bill.

With legislation shifting to the concept of long term, low emissions from automobiles and some states now requiring motorists to drive nonpolluting cars, the data suggest that the female, if she is required to maintain her automobile according to a set of standards, may be unable to interface with the repair facility from a knowledge level.

The detailed statistical analyses of brake repairs indicated that tire dealers had a significantly higher ($p \cong 0.001$) rate (38 percent) of unnecessary repairs than the other repair facilities (25 percent). On the other hand, owners performing their own repairs had a significantly ($p \cong 0.005$) lower rate (16 percent) of unnecessary repairs than the commercial facilities (25 percent). Also, 74 percent more owners performed their own repairs when they were given diagnostic information.

Brake system repair costs were grouped into three categories: under \$9, \$9-\$30, and over \$30. The first category is a typical cost of cleaning and adjusting the brakes. The second category is a typical cost of minor repairs or relining the brakes on a single axle. The third category is a typical cost of a complete brake job, such as relining all four drums. The results were 27 percent of the unnecessary repairs were below \$9; 38 percent of the required repairs were in this price range. On the other hand, over 32 percent of the unnecessary repairs exceeded \$30; only 22 percent of the required repairs exceeded this amount. As with engine repairs, it appears that an unnecessary brake repair is an expensive repair ($p < 0.001$).

Selected Component Repairs

The analysis at the component level consisted of evaluating only brake disc or drum, brake lining, rear wheel seal, control pivot arm, idler arm, lower ball joint, and shock absorber repairs. Repairs to these nine components represented 34 percent of the repair actions, 40 percent of the repair dollars, and 53 percent of the unnecessary repair costs for all critical system repairs.

Brake Components

Table 6 gives the unnecessary repair rates and costs for the selected brake components by type of repair facility. The most notable results are that 70 percent of the front disc or drum and 79 percent of the rear drum repairs performed by tire dealers were unnecessary. Also, 70 cents of the repair dollar spent for front disc or drum repairs and 67 cents of the repair dollar spent for rear drum repairs at tire dealers were unnecessary.

The new car dealers had a significantly ($p < 0.005$) higher unnecessary repair rate (50 percent) for front wheel lining repairs. On the other hand, the new car dealers had a low unnecessary repair rate (18 percent) for rear lining repairs. This anomaly cannot be explained at this time.

Chain stores had a significantly ($p < 0.05$) higher unnecessary repair rate (36 percent) for rear brake lining repairs. Also, 36 cents of every dollar spent at chain stores for rear brake lining repairs was unnecessary. Chain stores had a significantly ($p < 0.005$) higher unnecessary repair rate (67 percent) for rear wheel seals. Also, 57 cents of every repair dollar spent for rear seal repairs at chain stores was unnecessary.

Steering Components

Table 7 gives the unnecessary repair rates and costs for the selected steering components by type of repair facility. The tire dealers and the chain stores had a 53 percent unnecessary repair rate for idler arm repairs. Although this was the highest unnecessary repair rate, it was not significantly higher. Of the steering system unnecessary repair costs, 55 percent were due to control arm pivot repairs. All the repair facilities had a high unnecessary repair rate for control arm repairs.

Suspension Components

Lower ball joint and shock absorber repairs accounted for 96 percent of the suspension system unnecessary repair costs. Table 8 gives the unnecessary repair rates and costs for these components by type of repair facility.

There was no significant difference among the various types of repair facilities in the unnecessary repair rates of lower ball joints. However, 25 cents of every repair dollar spent for ball joints at independent facilities was unnecessary, while 45 cents of every repair dollar spent at the tire dealers was unnecessary. The tire dealers had a significantly higher unnecessary repair rate (55 percent) for shock absorber repairs. Also, 56 cents of every repair dollar spent for shock absorbers at tire dealers was unnecessary.

Repair Variations Within Type of Repair Facility

Figure 3 gives the unnecessary repair rates by specific car dealer. A chi-square test indicated that the variation in the unnecessary repair rates is significant ($p = 0.01$).

Dealers B and K had a significantly lower ($p \cong 0.005$) unnecessary repair rate. Dealer G had a significantly higher ($p \cong 0.015$) unnecessary repair rate. The out-of-Huntsville car dealers had a significantly lower ($p \cong 0.001$) unnecessary repair rate. This suggests that the car dealers in the small towns may be more sensitive to the effects of unnecessary repairs on their reputations.

Unnecessary repair rates by specific chain store were also analyzed. A chi-square test indicated that the variation in the unnecessary repair rates between individual stores is significant ($p \cong 0.001$) for the chain stores. For example, chain F contributed 73 percent to the chi-square and was the principal contributor to the nonuniformity in the unnecessary repair rates.

Discretion must be used in assuming that any one repair facility is good or bad based upon the performance of its particular type. For example, for all brake repairs, one merchandising chain only had a 26 percent unnecessary repair rate, while another chain had a 66 percent unnecessary repair rate. This may reflect local conditions such as labor, skill, or local and national management attitudes. In addition, the overall unnecessary brake repair rate for dealers of American-made cars varied from 18 percent to 35 percent. The public appears to be aware of these variations in the quality among the various repair facilities. The best performing chain did 252 percent more brake work than the poorest one. The new car dealer with the best performance did 70 percent more business than would

Table 7. Unnecessary repairs for selected steering components.

Component	Number Unnecessary Repairs	Unnecessary Repair Rate (%)	Unnecessary Repair Costs ($)	Unnecessary Repair Costs (%)
Idler arm				
Service station	1	17	30	23
Car dealer	9	32	251	37
Independent	4	19	102	22
Tire dealer	10	53	244	47
Chain	10	53	305	52
Individual	3	27	41	27
Control pivot arm				
Service station	4	80	150	78
Car dealer	10	83	357	92
Independent	15	83	543	86
Tire dealer	5	71	192	77
Chain	19	83	771	84
Individual	1	100	4	100

Table 8. Unnecessary repairs for selected suspension components.

Component	Number Unnecessary Repairs	Unnecessary Repair Rate (%)	Unnecessary Repair Costs ($)	Unnecessary Repair Costs (%)
Lower ball joint				
Service station	2	40	110	40
Car dealer	7	23	573	36
Independent	11	26	572	25
Tire dealer	8	47	428	45
Chain	8	40	392	40
Individual	2	22	63	27
Shock absorber				
Service station	7	37	243	33
Car dealer	6	25	272	31
Independent	9	33	336	40
Tire dealer	21	55	875	56
Chain	51	37	1723	43
Individual	6	32	171	33

Figure 3. Unnecessary repairs by specific car dealers, both in and outside Huntsville, Alabama.

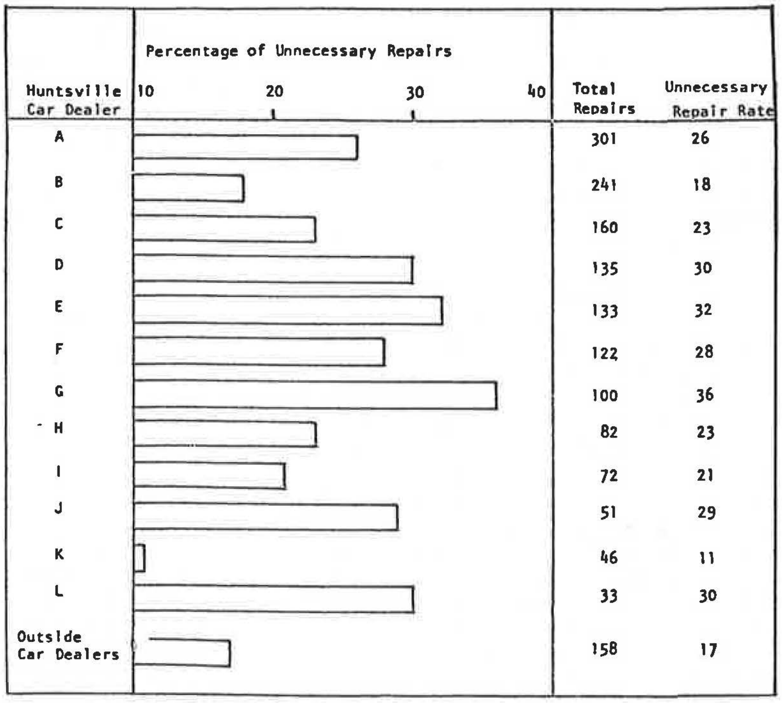


Figure 4. Effects of prescription form use on unnecessary repair rates, by repair facility.

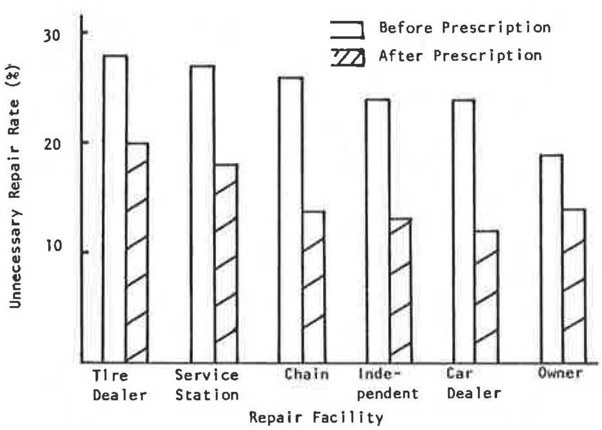
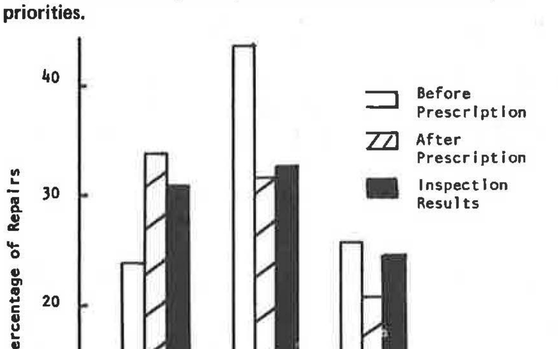


Figure 5. Effect of prescription forms on consumer's repair priorities.



have been expected based on the population of the vehicles that it sells.

SUPPLEMENTARY INFORMATION SUPPLIED TO THE PARTICIPANT

During the 3 years of the Auto Check program, several experiments were conducted in transferring the results of the diagnostic inspection to the participants so that the participants could interface better with the repair industry, and, hopefully, could minimize repair costs. Initially, the participants were given a copy of the inspection results, with the experimental group receiving the detailed results and the control group receiving more general results. In addition to these forms, an Auto Check counselor reviewed the inspection form with each participant.

Beginning in January 1976, the counselor gave the participants in the experimental group repair hint booklets in addition to the inspection form. Only those participants whose vehicles had either engine or brake outages or both were given the booklets. These booklets further explained the results of the engine and brake inspection results. Distribution of these booklets was terminated after July 1976.

Beginning in January 1977, the counselor gave all participants a prescription form which gave the participants the specific repair instructions to convey to the repair facility. Two prescription forms were actually used. One form was for engine-related outages, while the second form was for brake, tire, steering, suspension, and wheel alignment outages. The forms have a priority column where the counselor indicates the relative importance of each repair.

With only the inspection forms, the unnecessary repair rate was 25 percent. The use of the repair hint booklets reduced the unnecessary repair rate to 24 percent. The use of the prescription forms significantly reduced the unnecessary rate to 13 percent ($p < 0.0001$).

The unnecessary engine repairs were reduced from 33 percent to 16 percent after the participants were given the prescription forms. Likewise, the unnecessary brake repairs were reduced from 30 to 18 percent, unnecessary alignment repairs from 8 to 4 percent, and unnecessary suspension repairs from 36 to 19 percent. The unnecessary repairs for both males and females were significantly lower ($p < 0.01$) after they were given the prescription forms.

All repair facilities had a lower unnecessary repair rate after the introduction of the prescription forms (see Figure 4). The unnecessary repair rates were significantly lower for car dealers ($p < 0.0001$), independents ($p < 0.001$), and chains ($p < 0.01$).

The prescription forms had an effect on the consumer's repair priorities (see Figure 5). Prior to the prescription forms, 24 percent of all repairs involved the engine; after the prescription forms, 34 percent involved the engine. Normally, based on the inspection results, 31 percent of all repairs should have involved the engine assuming that the participants saw no risk in having any repairs made. Likewise, before the prescription, 44 percent of all repairs involved brakes, 26 percent alignment, and 7 percent suspension. After the prescription forms, 32 percent involved brakes, 21 percent alignment, and 13 percent suspension. These data compare favorably with the inspection results, indicating that 33 percent should have involved the brakes, 25 percent alignment, and 11 percent suspension.

The prescription forms also had an effect on the market shares of the repair facilities (see Figure 6). The chains and tire dealers increased their market shares at the expense of the service stations, independents, and owner repairs. The car dealers maintained their share.

Participants were asked: Who do you think provides the best repairs? This survey noted that 50 percent said independents, 27 percent car dealers, 15 percent chains, 6 percent service stations, and 1 percent tire dealers. Although only 1 percent thought that tire dealers gave the best repairs, 9 percent (of those going to a commercial facility) actually took their cars to tire dealers before the prescription form and this share increased to 13 percent with the prescription form. Tire dealers do a large amount of advertising and offer specials which are probably major factors attributing to this difference. It is possible that the prescription form reduced the participant's anxiety in dealing with a type of repair facility that he or she does not trust entirely in order to obtain the cost advantage.

REPAIR COST-EFFECTIVENESS

By reinspecting each vehicle after it was repaired, it was possible to calculate the cost-effectiveness of the repair facilities. Cost-effectiveness is defined as the total cost of necessary, unnecessary, successful, and unsuccessful repairs per successful repair. Necessary (required, recommended, optional) and unnecessary repairs have already been described. A successful repair is one that eliminates a previously observed outage, whereas an unsuccessful repair is one that does not.

The cost per successful repair, or cost-effectiveness, by system and by type of repair facility is given in the following table:

Repair Facility	Engine ($)	Alignment ($)	Brakes ($)	Suspension ($)
Service station	40.36	14.38	45.05	38.00
Tire dealer	28.33	14.22	47.18	49.45
Car dealer	31.82	15.65	35.85	38.17
Independent	48.74	12.98	41.23	48.30
Owner	34.64	12.00	24.99	27.69
Chain	41.18	14.22	51.46	35.67
Average	38.52	14.34	40.04	39.82

A considerable variation existed in the cost-effectiveness of the various types of repair facilities. The most cost-effective commercial facility type for engine repairs cost the public 42 percent less per successful repair than the least cost-effective type of facility. For brakes, the most cost-effective commercial facility type cost the public 30 percent less than the least cost-effective facility. However, one must not assume that, while a type of facility is efficient, any member of that type also would be efficient.

Table 9 presents the cost-effectiveness for the local members of the car dealer group. The average cost-effectiveness includes the cost of unnecessary repairs to perfectly satisfactory systems. (This explains why dealer L has an average cost-effectiveness greater than the cost-effectiveness of any individual system.) The cost-effectiveness for individual systems only includes the monies spent on systems that had a previously noted outage. Of the 12 car dealers, the six most cost-effective performed twice as many repairs as the six that were the least cost-effective; this fact suggests that a portion of the public may be aware of the shops doing the best work. Car dealer A is particularly notable in that, among all shops performing ten or more repairs on any one system or 30 or more repairs on all systems, it was the most cost effective for the engine, alignment, and brake systems; had the highest success rate for the engine and alignment systems; and stood at 82.4 percent in overall repair success.

AVERAGE VEHICLE REPAIR COSTS

The average vehicle repair costs were computerized for the major systems. On the average, the motorist spent $28.14 for a brake repair, $25.91 for an engine

Figure 6. Representation of market share of legitimate repairs experienced before and after prescription forms were introduced.

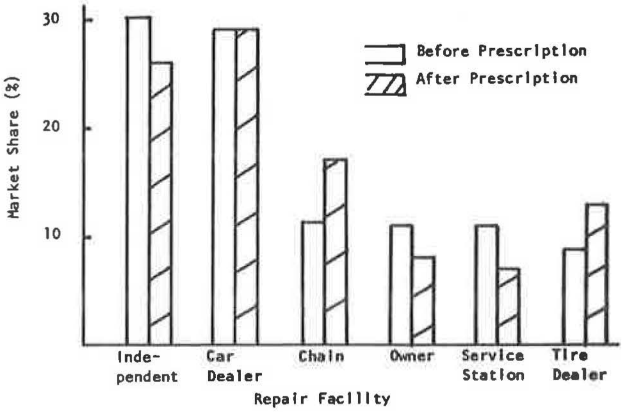


Table 9. Cost-effectiveness figures for various new-car dealers.

Dealer	Total Repairs	No. of Successful Repairs	$/Successful Repair: Engine	Alignment	Brakes	Suspension	Average
A	68	56	20.13	10.20	16.06	42.59	29.65
B	16	16	22.86	12.40	31.56	43.97	30.38
C	148	104	28.82	12.65	27.16	48.53	32.23
D	89	68	25.72	15.93	52.82	27.70	39.84
E	181	131	33.80	20.75	41.82	38.26	40.87
F	32	24	17.99	15.68	57.20	96.16	42.35
G	31	18	61.25	25.22	- -	- -	42.62
H	49	43	37.00	10.80	45.26	6.89	43.51
I	53	38	38.76	11.00	32.23	47.75	48.31
J	44	29	51.15	23.20	24.44	48.02	49.78
K	65	47	53.91	12.64	63.39	30.07	53.81
L	21	19	40.15	16.02	45.70	66.42	76.05

repair, \$15.65 for a steering repair, \$35.64 for a suspension repair, and \$10.22 for an alignment repair.

The average vehicle repair costs were analyzed by 2-month intervals for all the critical systems excluding steering. A regression analysis indicated that the overall average repair cost has increased by an estimated 12 percent, which approximates the rate of inflation.

In analyzing the data, there appears to be a learning function operating during the lifetime of Auto Check. Assuming that this learning effect does exist, then it is possible to estimate the amount of unnecessary repair costs motorists are saving by having their vehicles inspected at Auto Check. It can be assumed that the vehicle repair costs for the first time period are representative of a nonparticipant in Auto Check. Likewise, the vehicle repair costs for the last time period should be representative of an Auto Check participant. The difference in the cost would represent the potential savings to the consumer.

The average vehicle repair costs were analyzed by 2-month intervals for the engine and brake systems. A regression analysis indicated that the average unnecessary engine repair costs decreased \$4.41, while the average unnecessary brake repair costs decreased \$4.27. This suggests that a person participating in the Auto Check program may be saving up to \$8.68 in unnecessary engine and brake repairs.

CONCLUSIONS

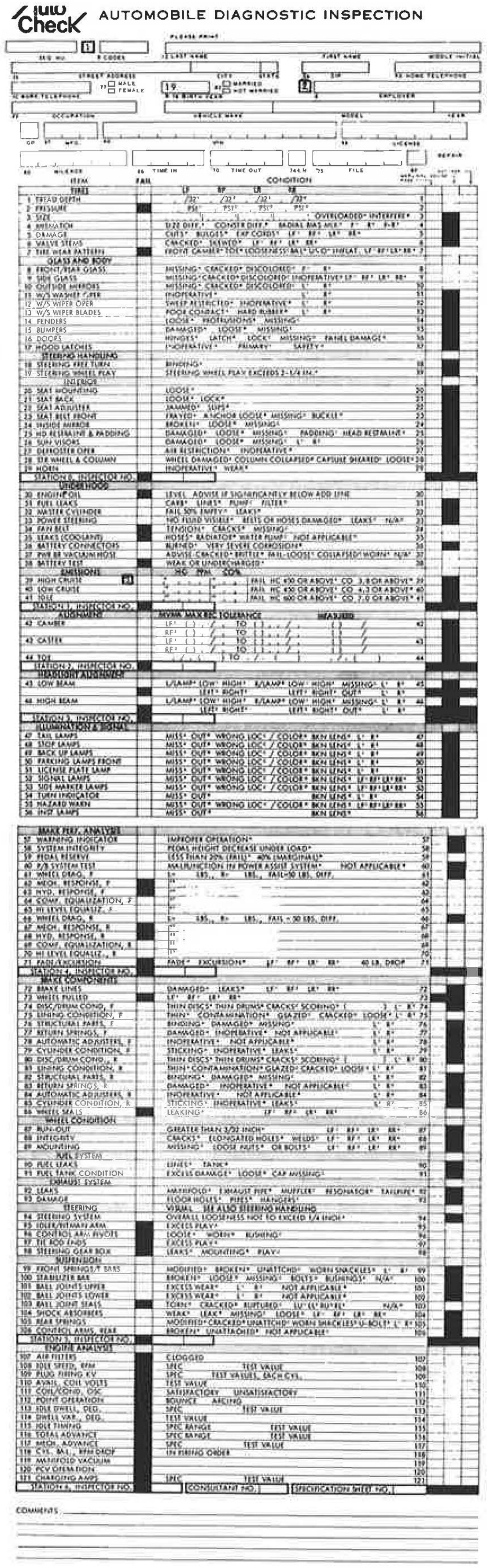
The results of this study, related to the local vehicle repair environment, are summarized as follows:

1. Of all engine, brake, steering, alignment, and suspension repairs, 25 percent were unnecessary. These unnecessary repairs represented 29 percent of the repair costs. After the participants were given the prescription forms as a means of communicating with the repair industry, the unnecessary repair rate was reduced to 13 percent.
2. High unnecessary repair rates were noticed for control arm pivots (82 percent), brake discs or drums (60 percent for rear and 58 percent for front), and rear wheel seals (47 percent).
3. Local car dealers who performed the most cost-effective repairs also had more than their share of the repair business.
4. Chain stores with the lowest unnecessary repair rates had the greatest business.
5. Out-of-Huntsville car dealers had a significantly lower unnecessary repair rate (17 percent) than the Huntsville car dealers (25 percent).
6. The rate of repair to the engine and suspension systems increased after the participants were given the prescription forms and reflect the rate of observed system outage.
7. The market share of the chains and tire dealers increased after the participants were given the prescription forms. Likewise, the market share decreased for service stations, independents, and owner repairs, but remained the same for car dealers.

From the above results, the following conclusions are made regarding the local repair environment:

1. Even with the results of a diagnostic inspection (see form reproduced in Figure 7), the consumer is still subject to, and agrees to, many unnecessary repairs.
2. The consumer has difficulty in communicating with the repair facility, even though detailed results of

Figure 7. Reproduction of Auto Check's automobile diagnostic inspection form.


Auto Check AUTOMOBILE DIAGNOSTIC INSPECTION

a sophisticated diagnostic inspection such as Auto Check are available.

3. The consumer is in a much better position to communicate with the repair facility if he or she has specific repair instructions to give the repair facility (i.e., prescription forms).

4. The consumer will be more likely to have the more costly and more sophisticated systems such as the engine repaired if he or she has the specific repair instructions to give the repair facility.

5. The consumer will change his or her habits and have car repairs done at different repair facilities if specific repair instructions are at hand.

6. The repair facilities that perform the best, most cost-effective repairs get the most business, suggesting that a good reputation (and performance to match) is critical to business success.

In summary, the results of the 3 years of operation of the Alabama motor vehicle diagnostic inspection demonstration program indicate that the cost of unnecessary repairs can be reduced, if effective communication techniques are used to transfer the results of the diagnostic inspection to the repair industry and if the repair industry is made aware of the financial effects of questionable repair practices.

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Portable Interactive Data Acquisition and Analysis System for Driver Behavior Research

B. C. Eatock and W. W. Demmery, Defence and Civil Institute of Environmental Medicine, Downsview, Ontario
R. D. Williams and D. A. Attwood, Road Safety Unit, Transport Canada

This report describes a portable interactive data acquisition and analysis system designed for roadway experiments studying driver behavior. The system is microcomputer-controlled and features multichannel sampling capability, on-line operator control of experimental parameters, and on-line data reduction capability. Several novel transducers are incorporated.

The Road Safety Unit of Transport Canada has a general requirement to perform measurements of driver behavior under actual driving conditions (1). The Defence and Civil Institute of Environmental Medicine (DCIEM), Ontario, was asked to provide a car-portable system to provide these measurements.

The general requirements for the instrumentation system were

1. True portability (it was to fit most North American cars, mid-size and larger; installation time of less than 24 h was desired);
2. Low power consumption;
3. Modular design;
4. On-line data analysis capability; and
5. On-line control over experimental procedures.

There can be as many types of instrumentation systems as there are road experiments. Performance of portable systems can be limited in many ways including sampling rate, data storage, degree of experimental control, power requirements, bulk, and cost.

Generally, a system's bulk, power requirements, and cost are directly related to its capability in terms of sampling rate, data storage, and experimental control. The more sophisticated experimental vehicles are typically equipped with fixed instrumentation and sensors. These are usually expensive, heavy, cumbersome vehicles, bearing more resemblance to portable laboratories than to the family automobile they are intended to simulate.

At the other extreme, the truly lightweight, low-power, inexpensive portable data recording systems are usually inflexible, often monitor few transducers, have slow sampling rates and limited data storage, and offer little control over the experimental parameters.