SEMIANNUAL VERSUS ANNUAL MOTOR VEHICLE INSPECTION: AN EVALUATION OF THE LITERATURE AND A BENEFIT-COST ANALYSIS

by

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(The opinions, findings, and conclusions expressed in this
report are those of the author and not necessarily those of
the sponsoring agencies.)

1874

The purpose of this report is to provide information comparing semiannual motor vehicle inspection systems with annual inspection systems. A review of the literature dealing with the similarities and differences between semiannual and annual programs was conducted. Some of the reports reviewed investigated the causes of motor vehicle accidents, while others examined the effect of periodic motor vehicle inspection on the mechanical condition of vehicles or vehicle accident rates. Also included were studies which examined the influence of age and mileage factors on the condition of vehicles. Generally, the literature supports an inspection system based on age and mileage factors. On the basis of the literature reviewed, a benefit-cost analysis comparing Virginia's semiannual inspection program with a theoretical annual inspection program was performed. The results showed that the annual program is more cost-beneficial, although semiannual programs may also return benefits in excess of costs to the public.

1876

1. A small percentage of motor vehicle accidents are caused
   by mechanical defects. An Indiana study concluded that
   vehicle related deficiencies were definite causes of
   6% of all accidents and probable causes of an additional
   10%.

2. The same study concluded that vehicles involved in
   accidents had more out-of-specification components than
   the general vehicle population. Also, the outage rates
   of components in vehicles judged to be most at fault
   in accidents exceeded the outage rates of the same
   components of other vehicles involved in accidents.

3. Studies have shown that vehicles in states requiring
   semiannual inspection are in better mechanical condition
   than vehicles in states having annual inspections. An
   estimate derived from the results in all of these studies
   shows that vehicles subject to a semiannual inspection
   are in approximately 20%-25% better mechanical condition.

4. No studies have demonstrated that adoption of a motor
   vehicle inspection program will result in a reduction
   in accident rates. Most studies encountered statistical
   problems which rendered the findings inconclusive.

5. Studies which compared death rates from motor vehicle
   accidents between states with semiannual inspection and
   states with annual inspection can be used to support
   either system, depending on which years' data are
   analyzed.

6. Two studies concluded that the probability of accident
   involvement does not increase as the number of months
   (up to six) since inspection increases.

7. Several studies have concluded that the mechanical con-
   dition of vehicles deteriorates as vehicle age and/or
   mileage increases. This fact opens up the possibility
   of varying the frequency, content, and depth of inspec-
   tions depending on vehicle age and/or mileage factors,
   if enforcement problems can be overcome.

8. The results of a recent public opinion poll conducted
   by the Virginia Highway and Transportation Research
   Council show that 71.6% of the Virginians polled favored
   semiannual inspection for all cars, while only 26.8%
   favored annual inspection.

9. In the benefit-cost analysis, the annual inspection
   program proved to be more cost-beneficial than the
   semiannual program, since the semiannual program costs
   twice as much as the annual program and is only 20%-

25% more effective.

10. The benefit-cost analysis showed that the current semi-annual inspection program is on the borderline of being cost-beneficial. If the level of program effectiveness exceeds 50% and the percentage of accidents caused by defects exceeds 6% (both figures are possible), then the program has a good chance of being cost-beneficial.

CONCLUSIONS

It is difficult to make a choice between semiannual and annual inspection programs solely on the basis of information in the literature. When a decision is made, however, it should not be based on comparisons of death rates from motor vehicle accidents between the two systems. First, the studies of death rates can be used to support either system, depending on which years' data are analyzed. Secondly, death rates are influenced by too many variables, which are generally left uncontrolled, for the influence of the inspection system to be effectively separated out.

The literature shows that at least a small percentage (6%-16%) of accidents are caused by vehicle defects, and that vehicles in states with a semiannual inspection program are in approximately 20%-25% better mechanical condition than vehicles in states having annual inspections. From these conclusions one would assume that a semiannual inspection program is more effective than an annual inspection program in reducing highway crashes. Although this assumption seems logical, all attempts to show a correlation between PMVI and lower accident and death rates have been unsuccessful, generally due to statistical problems.

The choice between two inspection programs is ultimately a question of cost effectiveness. The benefit-cost analysis showed that the current semiannual inspection program is on the borderline of being cost-beneficial. The data also showed that altering the present inspection program to an annual program would result in a more cost-efficient system. However, since there are conceptual and theoretical problems with measuring the benefits derived from a reduction in accidents in monetary units, the benefit-cost analysis should not be the sole basis for decision. Also, it is difficult to apply data derived from studies in other states to the inspection situation in Virginia. Variables such as the enforcement of inspection standards and the regulation of the system are important in determining program effectiveness. Since the inspection program in Virginia is one of the best administered programs in the country, it is likely to be more effective in reducing accidents than the programs in states with less regulation. These differences should be considered in the decision-making process.

The literature shows that vehicle condition deteriorates as vehicle age and/or mileage increases. If enforcement problems could be overcome, a program requiring the inspection of newer vehicles annually and older vehicles semi-annually would be beneficial. It would substantially reduce the costs of inspection to consumers while continuing the inspection of the more dangerous vehicles frequently.

1880

1880

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INTRODUCTION

Since the late 1920's, periodic motor vehicle inspection (PMVI) has been performed in various states. Virginia was among the first states to require inspections, implementing a semiannual PMVI program in 1932. Inspections are conducted throughout the year in privately owned stations licensed by the state. Vehicles are required to be inspected twice a year, with a period of no more than six months between inspections. This program is regulated and enforced by the Department of State Police.

In 1966, Congress passed the Highway Safety Act, giving the Secretary of Transportation authority to set standards for state highway safety programs. Highway Safety Program Standard No. 1, Periodic Motor Vehicle Inspection, was issued a year later. It requires each state to operate a motor vehicle inspection system under which "every vehicle registered in the state is inspected. . . at the time of initial registration and at least annually thereafter. . . ." [1] The federal standards were established with the threat of withholding highway related federal funds if a state did not comply with them. However, federal funds have never been withheld for noncompliance.

Currently, PMVI is mandatory in 28 states and in the District of Columbia, Puerto Rico, the Virgin Islands, American Samoa, and Guam. Eleven states have approved trial substitute programs, and 11 neither require PMVI nor have approved trial substitute inspection programs.

Action by the various states and the federal government to implement PMVI programs was based on the premise that a portion of highway crashes is due to defective mechanical components. Since under a PMVI program these defects should be detected and corrected before they lead to accidents, the program should lead to a reduction in accidents by improving vehicle maintenance. Although this hypothesis seems logical, critics of PMVI have charged over the years that there is no established association between the condition of motor vehicles and accident rates.

In recent years PMVI has come under increasing attack. New Mexico and Wyoming have repealed their inspection laws

within the last year. In Ohio, the state senate refused
to adopt an annual inspection program in lieu of the ran-
dom inspection program already in effect. However, a
majority of states still have PMVI programs or approved
trial substitute programs. Even though states recognize
the potential benefits from a PMVI program, they must
justify the high costs generally associated with such a
program. States which have abandoned or which have failed
to enact a PMVI program feel that the benefits do not
justify the costs. They think highway safety funds can
be put to more beneficial uses. States which continue to
require periodic inspections obviously feel that the costs
are justified.

Not surprisingly, the semiannual inspection program
in Virginia has come under attack in recent years. Opponents
have argued that an annual program would substantially
reduce costs to consumers while sacrificing little in high-
way safety. Proponents of the present system concede
that costs would decrease under an annual program; however,
they argue that changing to an annual program would sub-
stantially decrease the benefits in highway safety realized
under the semiannual system.

PURPOSE AND SCOPE

The purpose of this report is to review the literature
dealing with the similarities and differences between semi-
annual and annual inspection programs and, based on the
literature reviewed, to examine the benefits and costs of
each type of system. Accordingly, the report has two major
parts: (1) a literature survey, and (2) a benefit-cost
analysis.

In the literature survey, the following questions are
addressed:

1. Do mechanical defects cause accidents?
2. What is the ability of various inspection programs
   to detect and correct mechanical defects?
3. Is PMVI effective in preventing highway accidents
   caused by mechanical defects?
4. What is the effect of vehicle age and mileage on
   mechanical condition?
5. How do the citizens in Virginia feel about PMVI?

In evaluating these questions, specific attention is
paid to the similarities and differences between semiannual
and annual inspections. The benefit-cost study compares
Virginia's current semiannual inspection program with a
theoretical annual inspection program.

Before proceeding, the reader should be aware of the

limitations of the report. Although a substantial number
of studies on the subject of vehicle inspections have been
reported, relatively few of these compared semiannual and
annual inspection programs, the main reasons being the
statistical difficulties encountered in comparing programs
across state lines and the funding, implementation, and
statistical problems encountered in conducting intra-state
experiments. Despite these difficulties, this report does
provide information upon which a decision can be made.
However, the report may raise more questions than it answers.

METHODOLOGY

Literature Review

The basis of the report is a review of the literature
analysing PMVI and comparing semiannual inspection with
annual inspection. The literature survey was initiated
through a file search by the Highway Safety Information
Service of the Transportation Research Board and an
examination of a bibliography on PMVI published by the
National Highway Traffic Safety Administration (NHTSA).
Those reports which were believed to be related to the
issue of frequency of inspection were obtained for review.
Reference lists from the reports also were reviewed for
pertinent literature.

The studies reviewed for this report examined different
aspects of the PMVI issue. Some investigated the causes
of motor vehicle accidents, while others examined the effect
of PMVI on mechanical vehicle condition or vehicle accident
rates. Still others examined the influence of age and
mileage factors on vehicle condition. Particular emphasis
was placed on those studies which compared annual and semi-
annual inspection systems. The findings and conclusions
of each study are presented along with a critical analysis.
Comments are based on the views of researchers who have
examined these reports as well as the views of the present
author. From the literature surveyed, conclusions are
drawn which represent a synopsis of the state of the art on
motor vehicle inspection, and semiannual as opposed to
annual inspection in particular.

Benefit-Cost Analysis

In recent years, the use of benefit-cost analysis to
aid in political decision making has increased dramatically,
especially in the area of highway traffic safety measures.
Despite difficulties in measuring the benefits from a
reduction in accidents in monetary units, a benefit-cost
analysis can provide useful information concerning the
desirability of one program over another. For these reasons,
a benefit-cost analysis was performed.

The analysis compared Virginia's semiannual inspection program with a theoretical annual inspection program. The development of a benefit-cost model was based on the findings from the literature review. The only study found which performed a benefit-cost analysis of an operating semiannual inspection program and compared the results with an analysis of a theoretical annual inspection program was an evelution of Pennsylvania's program by the Carnegie-Mellon University. That analysis served as a guideline for the analysis of Virginia's inspection system, although some assumptions were changed to better reflect the findings of the literature review.

ANALYSIS

Literature Survey

Motor vehicle inspection programs are instituted on the assumption that a mechanically sound vehicle is safer than one with defects and therefore will be involved in fewer accidents. The literature review focused on studies which have examined the role of mechanical defects in accident causation, the ability of various inspection programs to detect and correct mechanical defects, and the effectiveness of motor vehicle inspection in reducing highway crashes. In addressing these issues, specific attention was paid to a comparison of semiannual inspection with annual inspection.

Do Defective Vehicles Cause Accidents?

The main purpose of PMVI is to improve highway safety by reducing the number of vehicles with defects that may cause or contribute to an accident, or that may increase the severity of accidents which may occur from other causes. In evaluating the effectiveness of a PMVI program, the initial inquiry must be into the causes of vehicle accidents.

In 1973, the Indiana Univeristy Institute for Research in Public Safety (IRPS) conducted an investigation of the factors which cause motor vehicle accidents.[2] The study concentrated on the vehicular factors which cause accidents. The study area was Monroe County, Indiana.

Data were collected on three levels. First, baseline data were assembled to permit definition of the project universe. These data demonstrated that Monroe County accident statistics were highly representative of the nation as a whole. Second, 999 accidents were investigated immediately after their occurrence by 2- or 3-man teams of technicians. Finally, 219 of those accidents were independently examined by a multidisciplinary team.

The study concluded that vehicle related deficiencies
were definite causes of 6% of the accidents investigated
by the multidisciplinary team and probable causes of an
additional 10% of the accidents. Vehicle defects also had
a probable involvement as severity increasing factors in
4% of the accidents. Vehicular factors alone (in the
absence of any human or environmental deficiencies) were
definite or probable causes in only 3% of all accidents.
This study shows that vehicle defects definitely cause
accidents, although the role defects play in accident cau-
sation is relatively minor. On the other hand, human
factors were involved in over 95% of the accidents inves-
tigated by the multidisciplinary team.

Deficiencies in the braking systems and the tires and
wheels were the defects most frequently cited as contributing
causes of accidents (see Figure 1). Sudden loss of the
front and rear braking capability of the vehicle was the
most frequent type of brake system failures. Excessively
turned drums was the dominant reason for this sudden loss
of pressure in the brake lines. The tire and wheel factors
which most frequently caused accidents were underinflation
and inadequate tread depth. Deficiencies in communications
(lights, signals, and vision), steering, and body and doors
contributed to fewer accidents.

During the period of the investigation conducted by
the IRPS, an independent study of component outages* in
the general vehicle-in-use population of Monroe County was
conducted by Ultrasystems, Inc. In comparing the pre-crash
safety condition of the vehicles involved in accidents to
the condition of general population vehicles, the IRPS
found that vehicles involved in accidents, regardless of
the principal cause of the accidents, tended to have higher
component outage rates than the general population vehicles.
It was also found that among the accident involved vehicles
inspected, there was a tendency for the outage rates of
the most-at-fault vehicles to exceed those for the other-
involved vehicles. This conclusion does not answer the
question of whether it is the defective vehicle that gets
the driver in trouble, or the bad driver who doesn't main-
tain the condition of his vehicle. The answer to this
question is important in determining the role of vehicular
factors in accident causation.

The results of these studies show that mechanical
defects cause at least a small percentage of vehicle acci-
dents. The authors also concluded that many of the vehicu-
lar factors that cause accidents can be detected and corrected
through a PMVI system. However, they do not examine the
effectiveness of PMVI in preventing motor vehicle accidents.

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* Outage means a component out of tolerance or specification
as inspected.

Recognizing the difficulty in demonstrating the relationship between PMVI and accident rates, many studies have examined the effect of PMVI on the mechanical condition of vehicles. The researchers feel that if vehicle defects cause accidents, and PMVI improves the mechanical condition of vehicles, then PMVI must lead to a reduction in accident rates.

Does PMVI Remove Defective Vehicles From the Road?

Several studies have examined the question of the influence of PMVI on the mechanical condition of the vehicle-in-use population. The first of these studies, conducted by McCutcheon and Sherman at the Highway Safety Research Institute (HSRI), compared samples of the vehicle populations
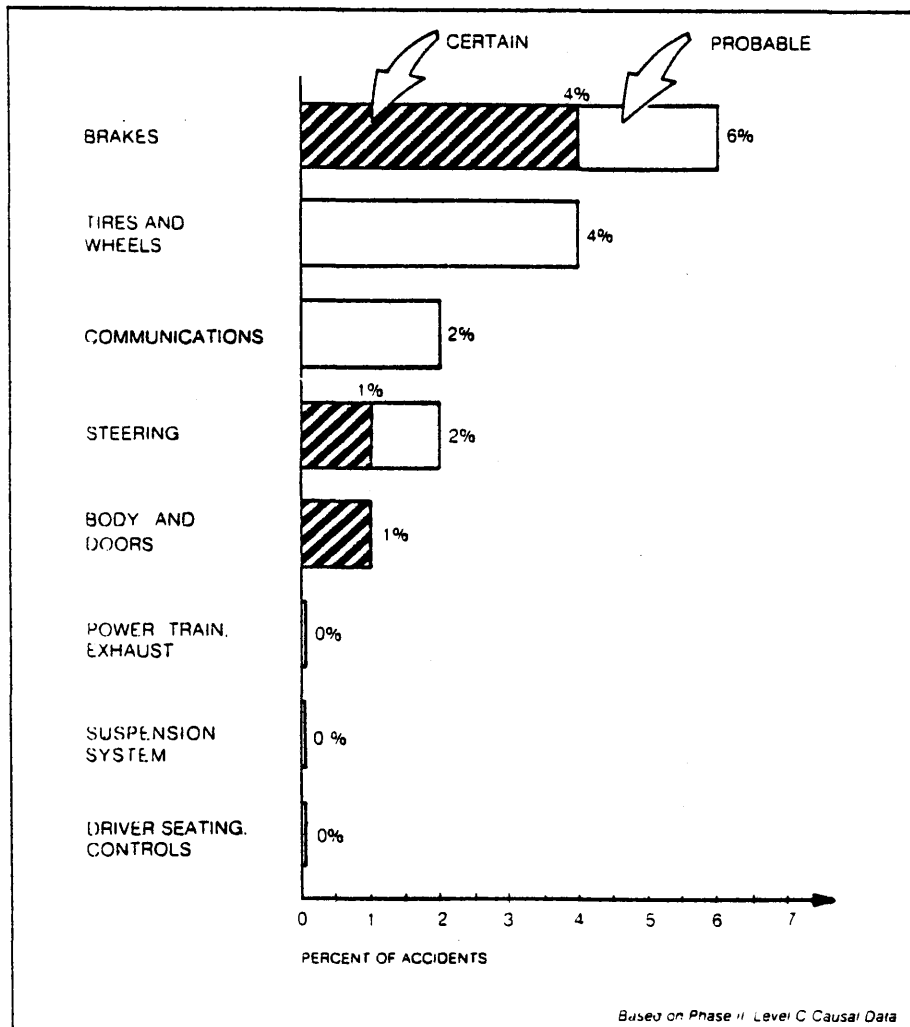

Figure 1.   Causes of motor vehicle accidents.
(From IRPS study in Indiana, reference 2.)

in Cincinnati, Ohio, which has semiannual inspections;
Washington, D.C., which has annual inspections; and Ann
Arbor, Michigan, which has random inspections. (3)

The data for Cincinnati and Washington were obtained
when vehicles passed through a lane-type inspection facility
for their regular inspection. The procedures used to
collect data in these cities were similar. The Ann Arbor
vehicles were selected randomly from street traffic and
directed to an inspection lane.

The results of the study indicated that the vehicles
subjected to PMVI were in substantially better mechanical
condition than the vehicles inspected randomly. The authors
found that as the frequency of inspections increased, the
mechanical condition of the vehicle population improved,
the rejection rate decreased, and the number of defects
per rejected vehicle decreased (Table 1).

For purposes of this report, it is important to note
the substantial differences found between vehicles inspected
in Cincinnati, with a semiannual program, and those in
Washington, D.C., with an annual program. The data indicated
that 42.6% of the vehicles inspected in Washington were
defective, while only 34.1% of those inspected in Cincinnati
were defective. However, the accuracy of the measurement
of the influence of inspection depends on holding all
other variables constant. McCutcheon and Sherman attempted
to select vehicle populations with reasonably similar
mileage, use, and exposure histories. The Washington and
Cincinnati vehicle populations appear to have been reasonably
similar, with the differences in median vehicle age and
vehicle mileage counteracting each other (Table 2). The
difference in per capita income, if it affects the results
at all, should lead to an increase in the mechanical quality
of vehicles in Washington, and, therefore, tends to diminish
the effect of the frequency of inspection. Nevertheless,
uncontrolled and undetected variables in any jurisdiction
could well account for some of the observed differences.
The differences noted are statistically significant at the
0.01 confidence level, however, and the results of the
study should not be disregarded.

TABLE 1

VEHICLE REJECTION RATES AND DEFECTS PER REJECTED VEHICLE

Inspections Per Year	Vehicles Inspected	Vehicles Rejected	Rejection Rate (%)	Total Defects	Defects Per Rejected Vehicle
0	591	555	93.9	1684	3.02
1	1249	532	42.6	1155	2.17
2	1665	568	34.1	891	1.57

TABLE 2

MEDIAN VEHICLE AGE, MEDIAN VEHICLE MILEAGE,
AND ANNUAL PER CAPITA INCOME

Location	Inspections Per Year	Median Vehicle Age	Median Vehicle Mileage	Median Miles/Yr.	Per Capita Income
Ann Arbor	0	2.8 Yrs.	29,500	10,536	$3,728
Washington	1	3.3 Yrs.	26,500	8,030	$3,367
Cincinnati	2	3.0 Yrs.	28,500	9,000	$2,639

A study by Ultrasystems, Inc. in 1971 investigated the
mechanical quality of vehicles operated under different types
of inspection programs.[4] The authors compared represen-
tative samples of the vehicle populations in Pennsylvania,
which has semiannual inspections; New Jersey and Washington,
D.C., which have annual inspections; and California, which
has random inspections. The samples, drawn by random sam-
pling techniques, were representative of both the national
vehicle profile and the profiles of the states from which
they were drawn. The vehicles chosen were given in-depth
inspections at diagnostic centers in each state. The authors
used elaborate controls, and they state that any conclusions
and inferences are based on data with high validity and
reliability and a statistical confidence of at least 95%.
Therefore, the results can be accepted with a high degree
of confidence.

A total of 2,476 vehicles were inspected; 500 from
Pennsylvania, 507 from New Jersey, 442 from Washington, D.C.,
and 1,027 from California. The authors concluded that based
on comparisons of overall outage rates, the vehicles sub-
jected to semiannual inspections were in significantly
better mechanical condition than the vehicles inspected
annually. Also, the vehicles inspected annually were in
significantly better condition than the vehicles inspected
randomly (Table 3). In Pennsylvania, 9.01% of all the com-
ponents tested were found defective; in New Jersey, 11.84%
were defective; and in California, 13.13% were defective.
These significant differences remained when the overall
outage rates were recalculated for each state omitting the
18 components not tested in Washington, D.C. (Table 4), and
when defect rates for safety-related components only were
compared. In Pennsylvania, 6.2% of components related
to safety were found defective; in New Jersey, 8.5%; and
in California, 9.7%. These results show that semiannual
inspection is significantly more effective than annual
inspection in improving the condition of vehicles.

TABLE 3

OVERALL COMPONENT OUTAGE RATES

Location	Total Outages Found	Total Component Tests Run	Overall Component Outage Rate (%)
Pennsylvania	4,679	51,956	9.01
New Jersey	6,193	52,294	11.84
California	13,417	102,153	13.13

TABLE 4

RECALCULATED OVERALL COMPONENT OUTAGE RATES

Location	Total Outages Found	Total Component Tests Run	Overall Component Outage Rate (%)
Pennsylvania	2,576	43,440	5.93
Washington, D.C.	2,851	38,332	7.44
New Jersey	3,911	43,792	8.93
California	9,304	86,947	10.70

A more recent study conducted by the NHTSA consisted of a survey involving 10,003 in-use automobiles in six states.[5] The states selected were Pennsylvania, with semiannual inspections; Missouri and Texas, with annual inspections; California, with random inspections; Maryland, with inspections at point of resale; and Illinois, with no inspection requirement. The purpose of the survey was to determine the influence of different motor vehicle inspection programs on the condition of vehicles in use.

The survey was conducted by measuring the condition of 53 components specified in the state inspection procedures. Only 34 of these components were included in the final analysis, since 19 had outage rates below 0.02 and were eliminated. Three different contractors collected the survey data using the same mobile motor vehicle inspection facility. NHTSA took precautions to ensure that the procedures used were consistent despite the personnel changes.

The overall results from the analysis indicated that motor vehicle inspection led to a reduction in outages of vehicle components. Further, a rigorous semiannual inspection program (Pennsylvania) produced lower component outage rates than both the annual programs (Missouri and Texas) and the random inspection program (California).

For the purposes of this report, it is important to compare closely the results from Pennsylvania with those from Missouri and Texas.

Pennsylvania has a rigorous semiannual inspection program. They inspect a total of 65 components and remove one

rear wheel and one front wheel for brake inspection. Both
Missouri and Texas have annual programs. Missouri inspects
51 components and removes one front wheel to check the
brakes. Texas inspects only 33 components and does not
remove any wheels to check brake condition.

For 28 components inspected in Pennsylvania, the com-
ponent outage rates were statistically contrasted with rates
in each of the other states. The results show that compared
to Missouri, 12 of the 28 components had significantly
lower outage rates in Pennsylvania, while 6 had significantly
lower rates in Missouri. These differences may be due to
the fact that vehicles in Missouri are inspected less
frequently and fewer components are inspected. When those
components which are not inspected in Missouri were eliminated,
8 out of 20 components had significantly lower outage rates
in Pennsylvania, while 5 had significantly lower rates in
Missouri. The results showed that multiple inspections
did improve the mechanical quality of vehicles. Texas
ranked as the worst state when compared to Pennsylvania,
with 22 components having significantly lower outage rates
in Pennsylvania and only 3 having significantly lower
rates in Texas.

Other variables must be considered before it can be
concluded that inspection results in better mechanical
condition of vehicles. In the vehicle population sampled,
Pennsylvania vehicles had a lower average total mileage than
vehicles in other states. The Pennsylvania sample also
contained more older drivers (55-65 years of age) than those
for other states. Finally, the average estimated income
of vehicle owners was higher in Pennsylvania than in either
Missouri or Texas.

The significant differences in these other variables
could possibly explain the differences in the component
outage rates just reviewed. Although the researchers
accounted for interstate variations in other portions of
the study, they did not control these explanatory variables
in the comparison of outage rates. This limitation should
be considered when viewing the results.

Other studies have examined the mechanical condition
of vehicles within a state. In 1972-73, New Jersey inspected
20,000 vehicles at random with a mobile inspection station.(6)
In computing the probability of rejection as a function
of months since inspection, they found that within 4 months
after the annual inspection the average car was as likely
to be rejected as it would be when presented for its next
annual inspection (Figure 2).

The results showed that vehicle condition did not
deteriorate much between 4 and 12 months after inspection.
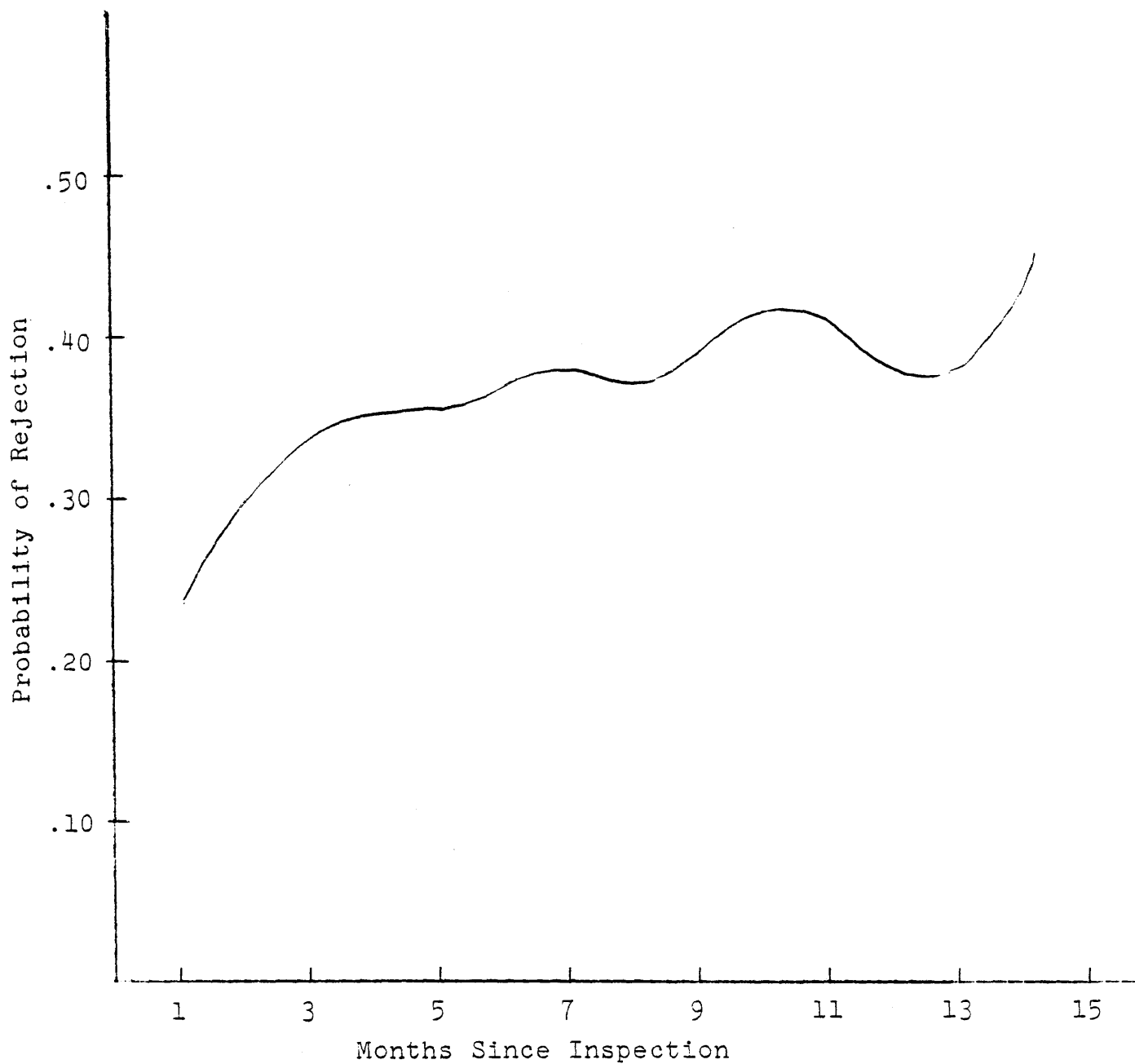This finding seems to support the case for annual inspections.

Figure 2.   Time since last inspection versus probability of
            rejection.   (From New Jersey study, reference 6.)

However, it should be noted that if vehicles were inspected twice a year, the vehicle population would be in better mechanical condition.

The Highway Safety Research Center at the University of North Carolina has studied the effect of inspection on vehicle condition in North Carolina since PMVI was introduced in 1966.[7] The results of their studies have shown that PMVI is effective in reducing the proportion of cars with defective components.

The studies cited in this section of the report have shown that vehicles in states with PMVI are in better mechanical condition than vehicles in states not requiring PMVI. More specifically, they have demonstrated that vehicle condition improves as the frequency of inspection increases. However, the findings from these studies do not conclusively support a case for or against any specific type of inspection program because they have not shown that PMVI leads to a reduction in motor vehicle accident rates.

Does PMVI Lead To a Reduction in Accident Rates?

Several types of studies have been conducted to demonstrate the effectiveness of PMVI in reducing accident rates. One type consisted of a comparison of death rates between PMVI and non-PMVI states.

A 1966 study by Buxbaum and Colton compared 1960 mortality rates from motor vehicle accidents among men between 45 and 54 years old in states with and without PMVI and in states with annual inspection versus states with semiannual inspection.[8] In the first comparison, they found that vehicle inspection was associated with lower mortality rates. This association prevailed when the states with and the states without inspection programs were grouped on the basis of geographic region, per capita income, population density, percentage of urban population, registered motor vehicles per population, and gasoline consumption per registered motor vehicle. Further, they found that states with two inspections per year exhibited lower mortality rates than states with only one inspection.

Buxbaum and Colton were careful to point out that their findings do not prove that motor vehicle inspection reduces accident rates. The findings show only that there was an association between lower death rates and vehicle inspection. A number of factors not related to PMVI could well account for their findings. Many of the demographic, geographic, meteorological, and social variables remained uncontrolled among the several states. Even the results from comparisons of the fatality rates for different sets of states grouped on the basis of geographical location are suspect. Variations within a geographic region in variables such as

traffic density, urbanization, quality of road building, and maintenance programs could contribute to the observed differences in mortality rates.

A more thorough analysis of the relationships between mortality rates and PMVI was conducted by Fuchs and Leveson using 1959-61 data.[9] Using multiple regression techniques, they examined the relationship between mortality rates and inspection status, motor fuel consumption per capita, population density, percentage of population 18-24 years of age, other accident mortality rates, percentage nonwhite, alcohol consumption per capita, percentage of vehicles more than 9 years old, whether or not states require vision inspection for license renewal, median years of education, and median income level. They concluded that inspection reduced mortality rates by as much as 5% to 10%. This reduction is considerably smaller than that found by Buxbaum and Colton. The data also showed that non-program factors such as income and education accounted for a much larger portion of the variation in fatality rates than did vehicle inspection.

With respect to the frequency of inspection, Fuchs and Leveson found that once interaction effects were taken into account, the effect of inspection was greater in states with more than one inspection per year than in those with only one. However, the difference between one and two inspections per year was not statistically significant.

Again, there is no evidence of causality between inspection and lower death rates. This study did satisfactorily control many potentially related variables, but many variables such as traffic density, quality of roads, and the ratio of rural to urban travel were omitted.

Both of the previous studies were conducted using pre-1964 accident data. Two NHTSA staff reports have updated these studies using 1968 data.[10]

The authors of one of the reports observed that during the 1950's, the average fatality rate for states with PMVI was significantly lower than the rate for states without PMVI. In the 1960's the difference began to narrow, and from 1966-68 the two rates were essentially the same. The report concludes that both the long-term and the short-term comparisons of fatality rates fail to demonstrate any marked influence of a PMVI program. There was no update of the data on the effect of frequency of inspections.

This report did not account for the effect of many other variables, such as income, geographic location, and degree of urbanization. Also, prior to 1960, inspection programs were found mainly in the northeastern region of the U.S. The states there have relatively high population densities and a high degree of urbanization. The states that have adopted programs since then have higher than

average death rates from motor vehicle accidents. These
are mainly large southern and western states.

To take account of factors such as these, in the research
presented in the second report a multivariate evaluation of
recent data was performed. The research examined the rela-
tionship between mortality rates and inspection status,
per capita income, percent white, mortality rate for nonwhite
persons in vehicle accidents, the ratio of rural to urban
travel, and alcohol consumption per capita. The result of
this analysis was that the use or nonuse of PMVI accounted
for 2% of the variance in mortality rates between the states
with PMVI and those without it. The authors concluded that
because of the importance of non-program variables, it
should not be expected that PMVI would reveal anything
better than a small reduction in total fatality rates.
Again, there was no update of the data to determine the
effectiveness of multiple inspections.

A recent study by Carnegie-Mellon University evaluated
Pennsylvania's semiannual inspection system.(11) From a
comparison of 1974 mileage death rates (MDR)*, it was found
that states requiring semiannual inspections, with a mean
MDR of 3.76, had approximately the same fatality rate as
states with annual inspections, with a mean MDR of 3.80.
There also was no statistically significant difference
between nonfatal injury rates in states with semiannual
inspections and those with annual inspections. In this
simple comparison of death rates, the authors did not con-
trol any of the other factors which can influence death
rate statistics.

The authors also conducted a slightly controlled study
of death rates in which data from states with similar cli-
mates, topographies, mean incomes, and latitudes were com-
pared. A group of states with semiannual inspection programs
had an average MDR of 3.2 while the states with annual
inspection programs had an average MDR of 3.7. Again, many
other influential variables were not controlled.

Throughout the debate over the effectiveness of PMVI,
both proponents and opponents have referred to death rate
figures. When death rates in PMVI states are significantly
lower than death rates in non-PMVI states, supporters of
vehicle inspection are quick to note those differences. On
the other hand, during periods when death rates among various
states are essentially the same, opponents of vehicle inspec-
tion refer to those statistics to demonstrate the ineffec-
tiveness of PMVI. In sum, fatality rate figures are used
by the group whose argument the data support at any given
time. However, most groups ignore the unreliability of

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* MDR = fatalities per 100,000,000 vehicle miles

comparing fatality rates among states. In these studies,
the effects of too many variables that can influence the
data were not included. The decision to continue or to
abandon a certain PMVI program should never be made solely
on the basis of death rate and accident rate statistics.

Other studies have attempted to show a direct rela-
tionship between PMVI and a decrease in accident rates.
In 1973, Reinfurt and Symons of the Highway Safety Research
Center at the University of North Carolina investigated the
effect of PMVI on highway crashes.[12] Using accident
data from the initial year of the inspection programs in
North Carolina and Florida, they analyzed the relationship
between PMVI and accident reduction. However, major prob-
lems were encountered in collecting data. In both states,
noncompliance with the phasing in schedules for the inspec-
tion programs was a major obstacle. Additionally, difficul-
ties with data file linkages of inspection, license plate
distribution, and corresponding accident information were
encountered in Florida. From the data examined, the authors
concluded that the effectiveness of PMVI in reducing the
number of accidents attributed to mechanical defects was
minimal. They suggested that the limitations in the data
and the probable small size of the effect, if any, of PMVI
on accident rates accounted for this finding.

A more recent study determined the effect of a volun-
tary inspection program, Autocheck, on the passenger vehicle
accident rate in Madison County, Alabama, from April 1975 to
April 1976.[13] The results of a statistical analysis by
Automated Sciences Group, Inc. did not present any strong
evidence that participation in the Autocheck program
resulted in a lower accident rate. However, there were
several limitations in the data collection process.
First, participation in the program was voluntary. Second,
participation and data analysis were restricted to 1968-
1973 model year vehicles. Third, there were difficulties
with data file linkages between Autocheck participation,
vehicle registration, and accident involvement information.
In light of other research, these limitations probably did
not significantly prejudice the results; however, they
should be considered when examining the findings of the
study.

Finally, two studies have examined the relationship
between accident involvement and time since last inspection.
Both studies analyzed accident data from states with semi-
annual inspection programs.

In 1969, Garrett and Tharp, using Virginia accident
data, examined the hypothesis that the probability of
accident involvement increases as the number of months
since inspection increases.[14] Analyzing the ratio of
accident to non-accident vehicles as a function of time
since inspection, the authors concluded that the data

did not support the hypothesis tested. They suggested several possible reasons for this result. First, inspection may not be effective in preventing accidents. Second, vehicle condition may not deteriorate sufficiently in 6 months to increase accident involvement. Third, since inspection can reduce only those accidents caused by vehicle defects, inclusion of all accident data may conceal any positive results. (If this is the only explanation for the results, inspection has a very limited effect on overall accident involvement.) Fourth, the use of uniformity assumptions to determine the distributions of elapsed times since inspection for vehicles not involved in accidents may not be sufficiently accurate.

Carnegie-Mellon University conducted a survey of accident data in Pennsylvania to investigate the relationship between the frequency of accidents and time since last inspection.[11] They studied and compared accident reports from January to June of 1975 for accidents classified into two groups. The control group consisted of a sample of accidents caused by tailgating. The authors assumed that this type of accident is caused by human factors, not by mechanical failures. The study group consisted of accidents caused by motor vehicle defects. The original hypothesis was that the frequency of accidents for the tailgating group would remain constant over time, while the frequency of accidents caused by defects would increase as time since inspection increased. This hypothesis was not supported by the survey findings. There are a number of possible explanations for this result. First, vehicle inspection may not be effective in preventing accidents. Second, vehicle condition may not deteriorate sufficiently in 6 months to increase the possibility of accident involvement. Third, the data collection procedures were inadequate. Incomplete record keeping in the reporting of accidents forced the authors to estimate the length of time since last inspection for the vehicles involved in accidents. Half of these vehicles had to be eliminated because the length of time since inspection could not be estimated for them. The result was a small sample size, with the most important variable being only a rough estimate of its true value.

None of these studies have successfully demonstrated that adoption of a motor vehicle inspection program will result in a reduction in accident rates. Each study encountered several problems with data collection which limited the conclusions reached. However, even without problems in compiling data, measuring the effect of PMVI on overall accident rates is a difficult task. First, mechanical defects cause only 6% to 16% of all accidents. Since no PMVI program can effectively reduce the accident rate by this much, any effect that PMVI would have on the overall accident rate would be relatively small. Secondly, many variables affect the accident rate in any particular state. It is difficult to control these variables when trying to measure the impact of PMVI on accident rates.

Does Vehicle Condition Deteriorate With Vehicle Age and Mileage?

Many researchers have looked at other issues in evaluating the effectiveness of motor vehicle inspection programs. Relevant studies have concluded that vehicle condition is a function of vehicle age and mileage. More specifically, these studies have concluded that vehicle condition deteriorates as vehicles get older and/or accumulate mileage. These studies have suggested the possibility of varying the frequency and/or intensity of vehicle inspections based on age and mileage factors.

A study by the Highway Safety Research Institute in Michigan found that vehicle age and mileage were important factors in determining whether or not a vehicle passed inspection.[15] A random sample of 6,000 vehicles representing a cross section of the population were inspected at roadside check lanes in three Michigan counties in 1973. Approximately 5,500 drivers were interviewed and their vehicles were inspected for the first time. Passing rates for these vehicles ranged from a high of 97.8% for 1973 vehicles to a low of 13.6% for pre-1964 vehicles. Highly significant differences were found for three groupings of vehicles: pre-1967, 1967-1969, 1970-1973 (Table 5). The author also found that owner characteristics such as income and age strongly affected vehicle quality. Generally, vehicles operated by younger persons and/or persons with lower incomes failed inspection more frequently.

TABLE 5

VEHICLE MODEL YEAR VS. VEHICLE CONDITION

Year	N	No. Pass	% Pass
1973	45	44	97.8
1972	933	791	84.8
1971	804	534	66.4
1970	649	381	58.7
1969	656	316	48.2
1968	592	228	38.5
1967	459	141	30.7
1966	358	77	21.5
1965	325	48	14.8
1964	220	32	14.6
Pre-1964	286	39	13.6
Unknown	122	52	43.0
1970-1973	2431	1750	72.0
1967-1969	1707	685	40.1
Pre-1967	1189	196	16.5

Among three: $X^2 = 1070.16$, df. = 2, p < .001
70-73 vs. 67-69: $X^2 = 420.27$, df. = 1, p < .001
67-69 vs. pre-67: $X^2 = 185.11$, df. = 1, p < .001

Studies by New Jersey and California verified these findings. In 1972-73, New Jersey inspected 20,000 vehicles at random with a mobile inspection station.[6] The results of the investigation showed that the percentage of vehicles found defective increased with vehicle age (Figure 3). Besides an increase in overall rejection rates with increased vehicle age, there was a general increase in rejection rates for individual components with increased vehicle age.

The California Highway Patrol analyzed data from a sample of 4,100 of the 1,100,000 vehicles which were randomly inspected in 1973.[16] The results showed that the older 50% of the vehicle population had about 75% of the safety related defects. Figure 4 depicts violation rates for safety related components as a function of vehicle age for vehicles with no prior inspection. The results support the findings of the previous studies by demonstrating that the likelihood of rejection increases with vehicle age. The authors recommended that California replace their random inspection program with a more cost-effective, selective random inspection program. This selective program would concentrate on inspecting vehicles four years of age and older.

An evaluation of Pennsylvania's semiannual inspection system by Carnegie-Mellon University analyzed data for a sample of 6,000 cars inspected at 248 stations throughout the state in the third period of the 1975 inspection cycle.[11] It was found that rejection rates increased with vehicle mileage and age. Mileage was found to be the better indicator of vehicle condition. Figure 5 shows that approximately 30% of the vehicles with less than 30,000 miles required some type of repair to pass inspection, while those with more than 80,000 miles had a rejection rate of over 40%. Rejection rates for the individual items inspected demonstrated this same trend.

The authors of that study proposed that vehicles less than two or three years old should be inspected only half as often as vehicles older than two or three years. They estimated that there would be a more efficient return from dollars spent in the number of defects found, if the inspection procedure concentrated on older vehicles.

In a study on the North Carolina inspection system conducted by the Highway Safety Research Center, the researchers concluded that there was a joint effect of vehicle age and mileage on the overall rejection rates.[7] As vehicle age and/or vehicle mileage increased, the percentage of vehicles failing inspection increased (Figure 6). From Figure 6 one can see that the rejection rate curves for various model years converge with increasing mileage, which indicates that the effects of mileage on rejection
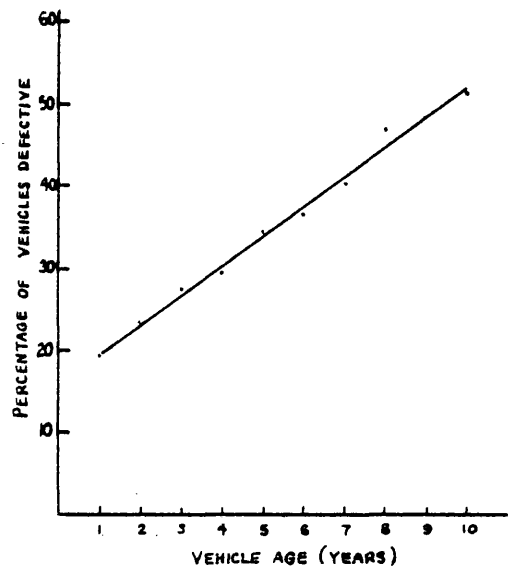
Figure 3.   Vehicle age versus defects.
            (From New Jersey study, reference 6.)

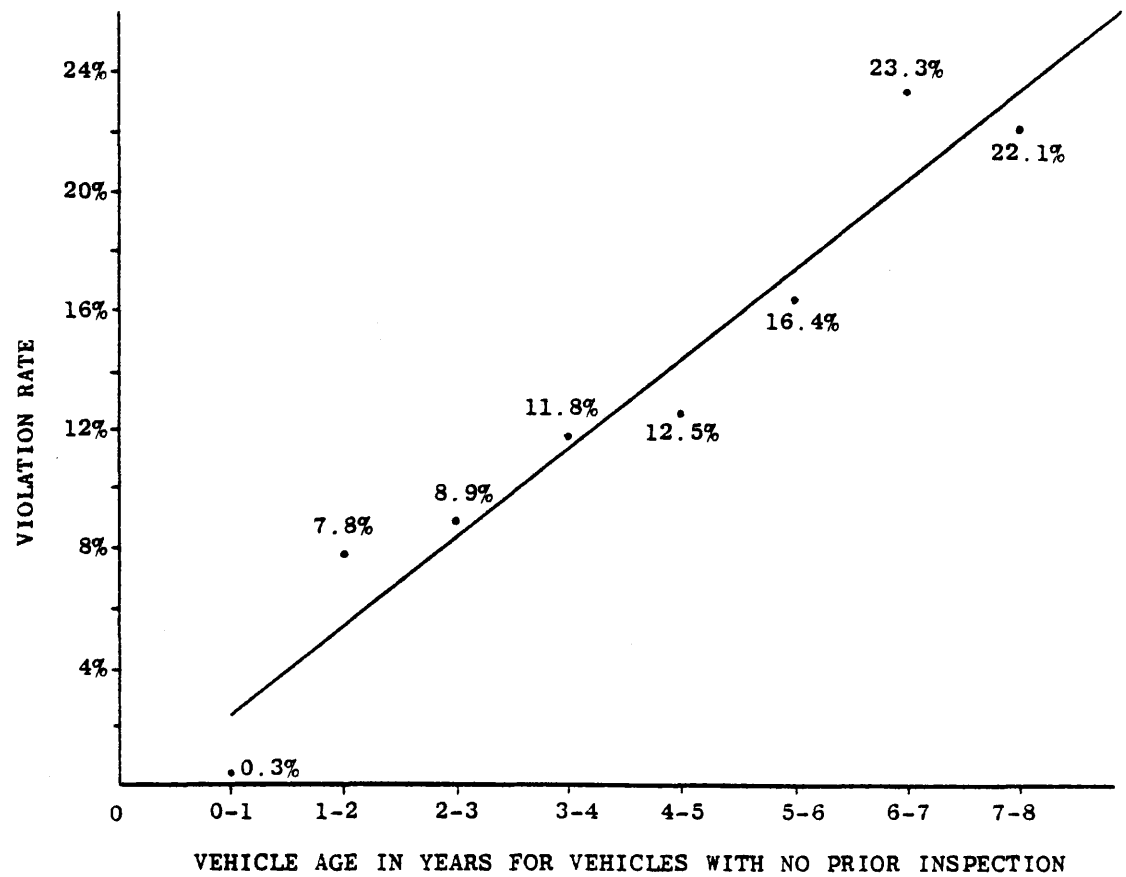VEHICLE AGE IN YEARS FOR VEHICLES WITH NO PRIOR INSPECTION

Figure 4.   Safety violation rates by vehicle age for vehicles
            with no prior inspection. (From California study,
            reference 16.)

- 19 -

% VEHICLES
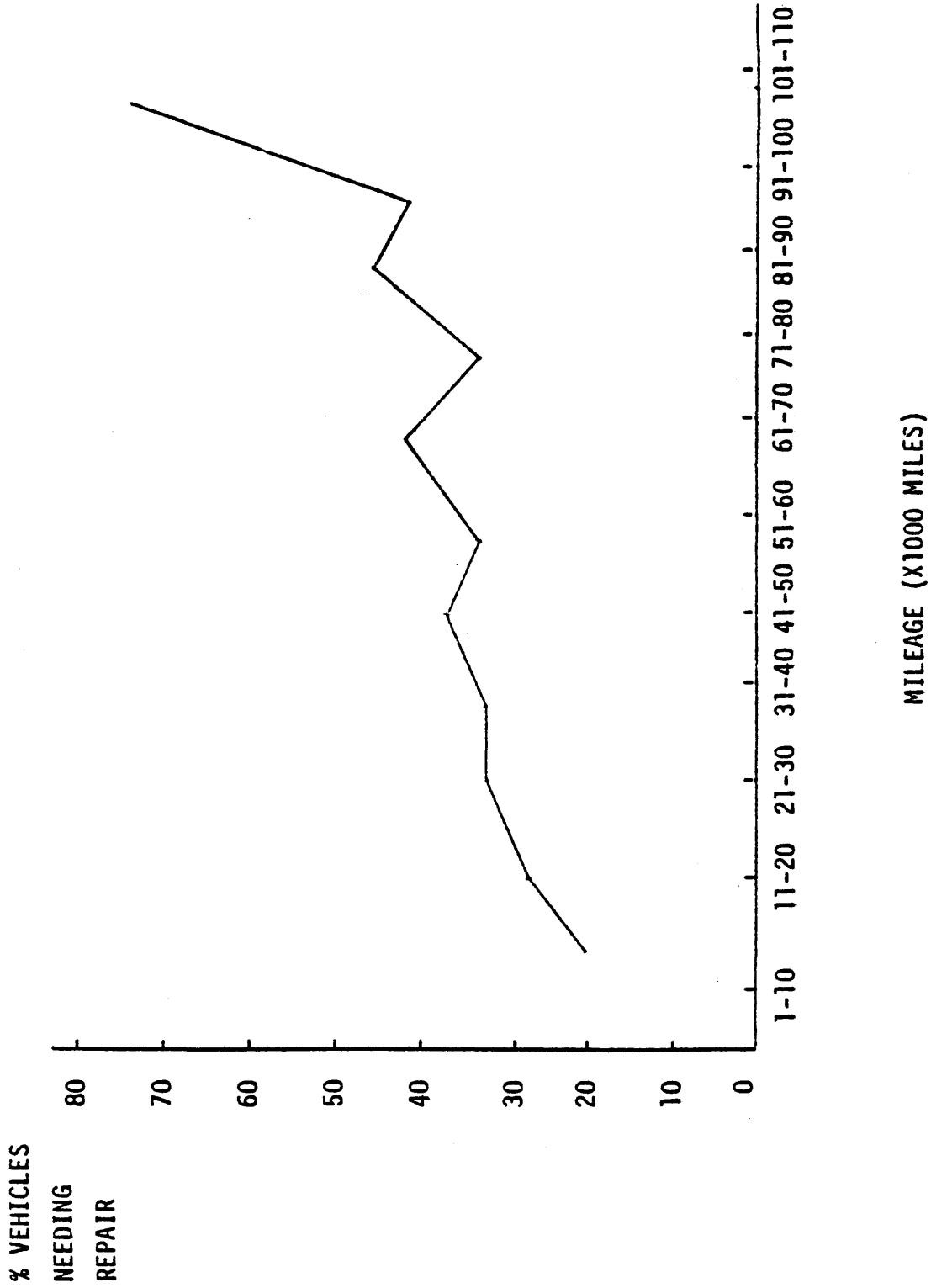NEEDING
REPAIR

MILEAGE (X1000 MILES)

Figure 5. Percentage of vehicles needing repair versus
accumulated mileage. (From Carnegie-Mellon
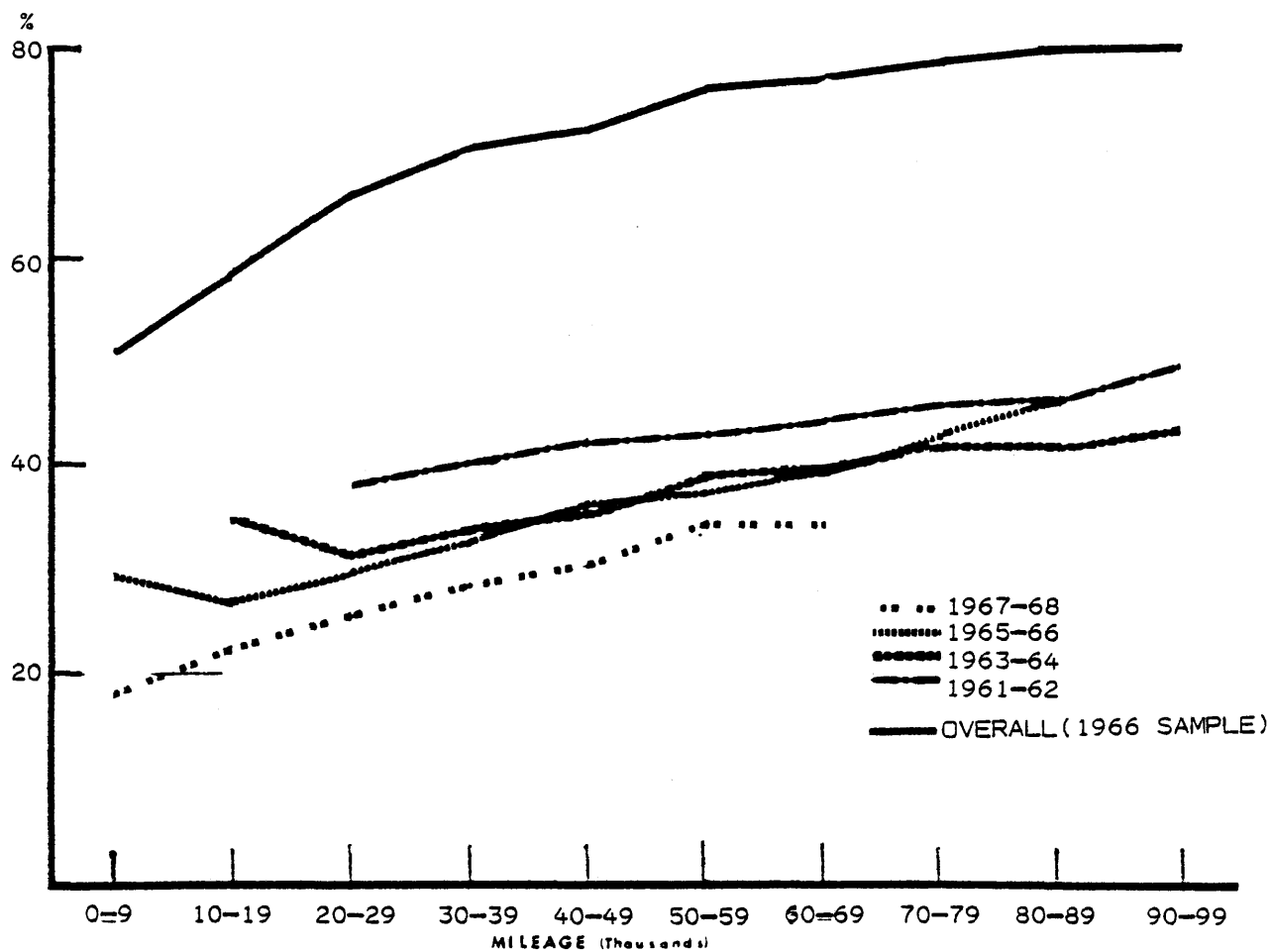study in Pennsylvania, reference 11.)

Figure 6. Percentage of vehicles with failures versus accumulated mileage. (From HSRC study in North Carolina, reference 7.)

rates are not the same for all model years. Accumulated
mileage seems to have a greater effect on newer vehicles
than on older ones. Thus, there is a joint effect of vehicle
age and mileage on the overall rejection rates. This trend
of rejection rates increasing with vehicle age and mileage
also existed for the individual items inspected. The
authors suggested the possibility of varying the content
and depth of inspection, depending on vehicle age and
mileage.

The consensus of the previously cited studies is that
the percentage of vehicles failing inspection increases
with vehicle age and mileage. To take these factors into
account, a program which varies frequency of inspection
with vehicle age and mileage could be instituted. Such
a program would allow new, low mileage cars to be inspected
less frequently than the older, higher mileage vehicles.
This type of inspection program could generate savings for
consumers with a minimum of additional safety hazard to
the public. However, enforcement would be very difficult
if frequency of inspection was based on mileage. This
practice would tempt consumers to turn back their odometers
to avoid the expense and inconvenience of additional inspec-
tions. Additionally, such an inspection program could
place an undue financial burden on low income groups who
generally own the more defective, older vehicles. These
enforcement and redistribution of income problems must
be considered in formulating an inspection system based on
vehicle age and mileage.

Inspection for new or low mileage vehicles must not
be totally eliminated. A survey of late model vehicles
conducted by the New York State Police in 1963 demonstrated
that safety equipment on new vehicles deteriorates with
time and use.[17] At the time of the study, New York law
required vehicles four years and older to be inspected
annually. The State Police set up a roadside inspection
station and checked 1958-1962 model vehicles for defects.
None of these cars had been previously inspected. The
results were compared with data on 1953-57 model vehicles
which had undergone periodic inspection in 1961. It was
found that failure rates were generally higher for the newer
vehicles inspected on the road than for vehicles subjected
to periodic inspection. The researchers recommended that
all vehicles be inspected periodically.

In Virginia, beginning in January 1978, new model
motor vehicles need only be reinspected within 12 months
of the first inspection.[18] Vehicles one year or older
must continue to be inspected once every six months.
Before there is another change in Virginia's inspection
system based on vehicle age or mileage, the effects of this
new law should be examined. If the results prove beneficial,
the requirement for only an annual inspection could be
extended to slightly older vehicles.

How Do The Citizens of Virginia Feel About PMVI?

Since consumer dollars are being spent on PMVI, consumer opinions should carry some weight in the decision-making process. A recent telephone survey by the Research Council randomly selected over 1,700 Virginians and asked their opinions on various highway safety issues.[19] Among the questions asked were several on motor vehicle inspection.

The results of the survey showed that 71.6% of the people favored semiannual inspections for all cars, while only 26.8% favored annual inspections. This preference for semiannual inspections is further supported by the fact that 85.3% of the persons polled approved of the current PMVI program. When told about the new law exempting one-year-old cars from the semiannual inspection requirement, 39.7% of the people preferred the annual inspection for new cars, while 58.3% were opposed to the new law. In addition, most people (93.1%) felt that having vehicles properly inspected would improve highway safety, although only 68.9% of the people felt that PMVI, as it currently operates, is efficient in detecting vehicle defects. This latter finding suggests that some people who support PMVI are dissatisfied with the way their vehicles are being inspected.

The results of this survey show that the majority of Virginians support a semiannual inspection program. In light of the difficulties in making a rational choice between semiannual and annual inspection based on the literature reviewed public opinion should be a factor in arriving at a final decision.

Benefit-Cost Analysis

Background

As previously stated, in recent years the use of benefit-cost analysis to aid in political decision-making has increased dramatically, especially in the area of highway traffic safety measures. There is a problem, however, in evaluating highway safety proposals in benefit-cost terms. To evaluate most highway safety programs, the benefits derived from a reduction in accidents must be measured in monetary units. Some economists believe that no decision can be based upon a study that measures such benefits in monetary units because the results are not economically relevant.[20] Despite these difficulties in measuring benefits, a benefit-cost analysis can provide useful information concerning the desirability of one program over another. This analysis compares Virginia's semiannual inspection program with a theoretical annual inspection program.

As noted previously, an evaluation of Pennsylvania's semiannual inspecton system by Carnegie-Mellon University was the only study found which performed a benefit-cost analysis of an operating semiannual inspection program and compared the results with an analysis of a theoretical annual inspection program,[11] and that analysis has served as a guideline for the present analysis of Virginia's inspection program, although some assumptions have been changed to better reflect the findings of the literature review.

The Pennsylvania study concluded that the state's semiannual inspection system was not cost-beneficial. A comparison of the semiannual program with a similar annual program showed that the benefit-cost ratios were roughly doubled by changing the frequency of inspection to once a year. However, this result was based on the assumption that the benefits derived under an annual inspection program would be the same as under a semiannual program. Once this assumption is made, the benefit-cost ratios must necessarily be smaller for semiannual inspection than for annual inspection since an annual program costs consumers approximately half as much as a semiannual program. The basis for assuming equal benefits for the two types of programs was a comparison of mileage death rate and nonfatal accident rate statistics for states with semiannual inspections with data from states with annual inspections. However, the literature review showed that any comparison of death rates and accident rates was suspect because there were too many variables left uncontrolled in a simple comparison of accident statistics for the results to be considered reliable.

The present analysis compared inspection programs on the basis of studies which examined the influence of different inspection programs on the mechanical condition of vehicles[3, 4, 5]. These studies concluded that vehicles subject to two inspections per year were in better mechanical condition than vehicles subject to only one inspection. From these studies, estimates of the relative effectiveness of semiannual inspections as opposed to annual inspections can be derived. These studies were selected for use because studies which have tried to show a relationship between specific inspection programs and a reduction in accident rates have proved inconclusive.

Benefits Considered

The major benefits from PMVI are the lives saved, the injuries prevented, and the property loss avoided by a reduction in the number of accidents. Research has shown that at least a small percentage of accidents are caused by mechanical defects.[2] However, before these benefits from PMVI can be calculated, the effectiveness of inspection in reducing accident rates must be estimated.

This is an area in which problems in benefit-cost analyses 19-5
of PMVI generally are encountered. The effectiveness of
any type of inspection program in preventing accidents
has never been successfully documented. Research has shown
that vehicles in certain states with semiannual inspections
were in better mechanical condition than vehicles in other
states with annual inspections. However, these studies
did not indicate the degree to which inspection programs
or the frequency of inspection reduced accidents. Attempts
to prove such a relationship have run into statistical prob-
lems that have rendered the studies inconclusive. For
this reason, various estimated levels of effectiveness for
PMVI were used throughout the present analysis.

It has been suggested that the proper maintenance of
vehicles extends the service life and reduces maintenance
costs. The influence of PMVI on the service life of vehicles
has never been quantified and was omitted from the analysis.
Also, since there is no clear consensus that PMVI has an
influence on overall maintennace costs, a determination of
benefits in the form of lower maintenance costs was omitted.

An additional benefit is the reduction in air pollution
resulting from proper functioning of the pollution control
devices on vehicles that is encouraged by inspection.
In regards to air pollution, several studies have concluded
that the testing of auto emissions substantially benefits
a state.[21, 22] However, no study has compared these
benefits as derived from semiannual as opposed to annual
inspections. Virginia presently inspects the antipollution
devices required on recent model vehicles. However, the
quality of auto emissions is not tested. It is impossible
to estimate the possible benefits from this practice in
Virginia.

Finally, unlike other states, Virginia collects no
revenues from the inspection system. The potential benefit
was, therefore, omitted.

Costs Considered

The major cost of PMVI to consumers is the price of
inspections. Effective July 1976 the fee for vehicle
inspection in Virginia was raised to $4. Since inspections
are required once every six months the total cost of inspec-
tions is $8 per vehicle per year. This fee covers only
the inspection procedure. Any repairs which are required
for the vehicle to pass inspection result in additional
costs to consumers. However, there are no available data
on the increase or decrease in repair costs due to an
inspection program, so an estimate of the influence of
PMVI on repair costs was not made.

Another major cost to consumers is that for the time

and travel required by the inspection process. It is dif-
ficult to estimate the average time spent and the average
miles traveled by consumers to comply with the requirement
for inspections. In Virginia, there are over 3,000 official
inspection stations located throughout the state. For
some consumers, costs of compliance are substantial since
they must travel long distances and wait for their cars
to be inspected. For others, the station is only a few
blocks away and the vehicle can be dropped off and picked
up later. Further, some people include the inspection as
part of their regular maintenance program and see it as
no additional cost.

An estimate of time and travel expenses was included
in the model developed in the Pennsylvania study.[11] This
estimate was based on an average of one hour spent and three
miles travelled per inspection. Although this time base
appears excessive, the final value of $26.5 million for
14 million inspections seems reasonable. The value given
to the time spent is also an important figure in determining
the final cost to consumers. This figure varies according
to the wages of the consumer and the amount of time lost.
The Pennsylvania study did not give details on the value
of time used, but it must have been relatively low for the
authors to arrive at the final figure they did. If time
was valued at $2.00 per hour, the time expenses would have
exceeded the final value for time and travel expenses used
in the study. To avoid valuation problems, the present
analysis used a conservative figure for the costs of time
and travel to consumers.

The other costs of inspection are the administrative
costs to the state. The inspection program in Virginia is
funded entirely from consumer dollars and state funds.
Inspection stations do not have to purchase licenses or
stickers and pay no fees to the state. The entire $4
inspection fee goes directly from the consumer to the
station. The costs to the state include regulation of
inspection stations, training, examination of inspection
mechanics, and general administrative costs of the program.
The enforcement and regulation of the inspection program
by the state police is an important aspect of the Virginia
system.

This concludes an outline of the major benefits and
costs of PMVI that will be included in the analysis.
Following are the calculations of those benefits and
costs.

Calculation of Benefits

The total societal benefits of any PMVI program equal
that portion of the total societal costs of motor vehicle
accidents that are prevented by the system. The first step

in calculating the benefits of the PMVI program was to compute the societal costs of fatalities, injuries, and property damage resulting from accidents. The second step was to estimate effectiveness of the program in reducing accidents. Next, the percentage of accidents caused by vehicle defects was determined. Finally, the number of fatalities and injuries and the amount of property damage from motor vehicle accidents were determined.

There are many problems in the calculation of benefits from a PMVI program. The major problem is the valuation of fatalities and personal injuries. The proposition of valuing lives and injuries has been a subject of debate. Many researchers argue that such a valuation should not and cannot be made.[20] They feel that savings in lives and reductions in the frequency and severity of accidents cannot be reasonably quantified in monetary units. If the principal benefits anticipated are of this type, then serious theoretical and conceptual difficulties arise. Others argue that a figure must be derived if benefit-cost studies of highway safety programs are to be carried out. Therefore, any value placed on a life is only a rough estimate. Other problems with the valuation of life and limb are the choice of factors to be included in the valuation and the choice of a discount rate.

Calculations of the societal costs of fatalities, injuries, and property damage resulting from accidents in 1975 follow.

The figures used by the National Safety Council (NSC) in calculating the costs of accidents include wage loss, medical expense, insurance administrative costs and property damage (see Table 6).[23] The NHTSA figures include wage loss, home production loss, medical expense, funeral costs, legal expenses, insurance administration, property damage, losses to others, and traffic delay.[24]

The wide variation in the two sets of figures is representative of the divergent views in this area. As an example, estimates of the societal costs for a fatality have ranged from $90,000 up to $500,000.[11]

TABLE 6

Societal Costs of Accidents

| | Per Case Costs | |
	National Safety Council	NHTSA
Fatalities	$110,000	$287,175
Nonfatal Disabling Injury	4,200	8,085
Property damage accident	570	520

In the analysis made, two sets of figures representing divergent views were used (see Table 7). Neither set exactly represents any particular study, but they represent estimates

which fall within the range of values derived in several studies.

TABLE 7

Societal Costs of Accidents

	Per Case Costs	
	A	B
Fatalities	$120,000	$250,000
Nonfatal Disabling Injury	5,000	7,000
Property damage accident	500	600

The other major problem with calculating the benefits of PMVI is the uncertainty associated with the assumed level of program effectiveness. Program effectiveness is the ability of the inspection procedure to prevent accidents caused by vehicle defects, and no study has estimated the effectiveness of any particular type of inspection program. In the present analysis, various levels of program effectiveness were assumed. For the annual inspection program, these levels were 12%, 40%, and 64%.

The studies on the influence of PMVI on mechanical condition found that vehicles subject to semiannual inspection were in approximately 20%-25% better condition than vehicles in states with annual inspection.[3, 4, 5] On the assumption that this difference in mechanical condition reflects the difference in effectiveness between these two types of PMVI programs, the correlating effectiveness levels for the semiannual program were taken as 16%, 50%, and 80%.

The final two factors that must be determined in calculating the total societal costs of PMVI present fewer problems. First, the percentage of accidents caused by vehicle defects must be determined. The Indiana study concluded that vehicle defects were definite causes of 6% of all accidents and probable causes of an additional 10%.[2] This is the most reliable study done on this subject and its results were used in the present analysis. The values used were 6%, 11%, and 16%.

How do these figures correspond to the actual accident statistics in Virginia? In 1976, 3.8% of all vehicles involved in crashes were defective, while 6.3% of all vehicles involved in fatal crashes were defective.[25] Additionally, 7.0% of all accidents involved a defective vehicle. These figures were derived through routine accident investigation procedures. The vehicle-in-use population was inspected twice a year. Although there is no way to tell what the statistics would be if there was a different inspection program or no inspection, it is safe to say that the figures derived in the Indiana study are representative of Virginia data.

Finally, accident statistics for the state had to be determined. The 1976 <u>Virginia Crash Facts</u>, published by the Department of State Police, reports the number of fatalities and injuries from motor vehicle accidents during the year. It also reports the number of vehicles involved in property damage only accidents. The statistics for 1976 are:

Fatalities	1,020
Personal Injuries	53,120
Property Damage Only	166,662

These figures were calculated from all accidents occurring in Virginia during 1976. There are several limitations to these data, however. First, they include both Virginia and out-of-state vehicles. It is known that approximately 85% of the vehicles involved in accidents were registered in Virginia. However, the numbers of fatalities and injuries resulting from accidents involving these vehicles are not known. Similarly, most of the literature dealt specifically with passenger vehicles, but the accident results include all vehicles. While it is known that approximately 82% of the vehicles involved in accidents were passenger vehicles, the numbers of fatalities and injuries resulting from accidents involving passenger vehicles are not known. These data could probably be collected with more time; however, without them, the accident statistics used in the present analysis are probably too high.

The calculations of the total societal costs of accidents in Virginia were derived by multiplying the number of fatalities, injuries, and property damaged vehicles by the corresponding dollar value estimates (i.e., the cost of fatalities would be equal to (1020)($120,000) = $122,400,000). Table 8 gives both sets of figures for estimating the societal cost of fatalities, injuries, and property damage that were presented in Table 7.

The proportion of total societal costs that are benefits of PMVI is derived by multiplying the values in Table 8 by the percentage of accidents caused by defects and by program effectiveness. Table 9 presents the societal costs of accidents caused by vehicle defects. These data were calculated by multiplying the values of the societal costs of accidents derived in Table 8 by the percentage of accidents caused by defects. The figures represent the maximum potential benefits from a PMVI program for the various estimates of accidents caused by defects and values assigned to fatalities and injuries.

TABLE 8

Total Societal Costs of Motor Vehicle Accidents in Virginia, 1976

Type	Number	A Cost per Case	Total Societal Loss
Fatalities	1,020	$120,000	$122,400,000
Injuries	53,120	5,000	265,600,000
Property Damage	166,662	500	83,331,000
			$471,331,000
		B	
Fatalities	1,020	$250,000	$255,000,000
Injuries	53,120	7,500	398,000,000
Property Damage	166,662	600	99,972,000
			$753,372,000

TABLE 9

Societal Costs of Defect-Caused Accidents in Virginia

Defect-Caused (%)	Total Societal Cost A	Total Societal Cost B	Defect-Caused Cost A	Defect-Caused Cost B
6.0	$471,331,000	$753,372,000	$28,279,860	$45,202,320
11.0	471,331,000	753,372,000	51,846,410	82,870,920
16.0	471,331,000	753,372,000	75,412,960	120,539,520

Calculation of Costs

The calculation of the costs of specific PMVI programs is relatively straightforward. The major costs of any inspection program are the costs to consumers. In Virginia, all vehicles must be inspected twice a year for a fee of $4 per inspection. In 1976, there were approximately 6,500,000 inspections in Virginia. Multiplying these values results in a figure of $26,000,000 in fees collected for inspections. A similar annual program would conduct 3,250,000 inspections. Assuming the inspection fees remain the same for the annual inspections, stations would collect $13,000,000 in fees from consumers.

An additional cost to consumers is the value of time and travel expended in order to comply with the inspection requirement. The problems associated with estimating these costs have already been discussed. This author feels that a conservative average figure is $1 per inspection. If the minimum wage is taken as the value of time, one dollar is the cost of less than 30 minutes. Inspections are usually conducted within a 30-minute period. Also, it is reasonable to assume that people spend as much time delivering and picking up their vehicles as is spent in inspecting them. When gas and travel costs are added to time costs, the $1 per inspection figure seems very conservative. With this assumption, the total cost of time and travel to Virginians

for semiannual inspections is $6,500,000. The corresponding costs to consumers for annual inspections would be $3,250,000.

The final costs considered in the analysis were the costs of administering the program. The 1976 State Police Report on the status of Virginia's inspection program gives the administrative costs at approximately $510,000.(26) This figure includes all items such as stickers, postage, salaries of supervisory and administrative staff, and depreciation on office equipment. Assuming that administrative and enforcement costs would remain relatively stable with a conversion to an annual program, the administrative costs of an annual program would be approximately $510,000, the same as for the semiannual program. Total costs are listed in Table 10.

TABLE 10
Total Costs of PMVI, 1976

	Semiannual	Annual
Inspection Fee	$26,000,000	$13,000,000
Time, Travel of Consumer	6,500,000	3,250,000
Administrative	510,000	510,000
Total	$33,010,000	$16,760,000

Break-Even Effectiveness

The effectiveness of a particular PMVI program in preventing accidents caused by vehicle defects has never been successfully documented. Therefore, program effectiveness must be estimated from other factors. One way to evaluate a PMVI program is to calculate the potential benefits from the program and then derive its break-even effectiveness. Table 11 presents the break-even effectiveness for annual and semiannual inspection programs for the three assumed levels of accidents caused by defects. Break-even results show the level of program effectiveness at which total benefits just equal total costs of PMVI.

The cost of semiannual inspections is $33,010,000. If it is assumed that 6.0% of accidents are caused by defects, then the potential program benefits, using the costs of accidents in Set A, would be $28,279,800. In this case, the system would have to be 117% effective to make the benefit-cost ratio equal one. Under these assumptions, even if the program was 100% effective in reducing accidents caused by defects, total costs could not be recovered. This is the only instance illustrated in Table 11 in which total costs could not be recovered. However, one cannot expect a program to be 100% effective. Some research has indicated that 75% is the maximum level of effectiveness obtainable.(11)

TABLE 11

Break-Even Program Effectiveness

Program	Total Cost	Defect Caused (%)	Potential Program Benefits A	Break-Even Effectiveness A	Potential Program Benefits B	Break-Even Effectiveness B
Semiannual	$33,010,000	6	$28,279,860	117%	$45,202,320	73%
		11	51,846,410	64%	82,870,920	40%
		16	75,412,960	44%	120,539,520	27%
Annual	$16,760,000	6	28,279,860	59%	45,202,320	37%
		11	51,846,410	32%	82,870,920	20%
		16	75,412,960	22%	120,539,520	14%

One should observe the differences between the figures for annual and semiannual inspections in Table 11. Under any set of assumptions, an annual program need only be half as effective as a semiannual program to recover costs. Therefore, if semiannual inspection is not at least twice as effective as annual inspection in preventing accidents, then the annual program will be more cost-beneficial.

Research has indicated that vehicles subject to semiannual inspections are in approximately 20%-25% better condition than vehicles in states with annual inspection. Assuming that this difference in mechanical condition reflects the difference in effectiveness between these two types of PMVI programs, an annual program would be more cost-beneficial than a semiannual program. This notion will be further developed in the next section.

The determination of actual program effectiveness is necessary to compute the real benefits of PMVI. However, data in this area are lacking and previous research efforts have been unsuccessful in determining motor vehicle inspection effectiveness. Therefore, in the next section, benefit-cost ratios are computed over the relevant ranges of effectiveness.

Benefit-Cost Ratios

The usual end product of a benefit-cost analysis is a single ratio upon which a decision is made concerning the efficiency of a program expenditure. In analyzing PMVI, however, it is impossible to derive one final figure. The analysis requires estimation of the societal costs of accidents, the level of program effectiveness, and the percentage of accidents caused by vehicle defects. None of these parameters can be reduced to one conclusive figure. Instead, it is better to compute a number of benefit-cost ratios by varying the parameters over ranges into which they most likely will fall.

In the tables which follow, benefit-cost ratios are given for a semiannual and an annual inspection program over the relevant ranges of various factors. The estimates of these parameters were derived and explained in the section on benefit calculations. Briefly, the values for the percentage of accidents caused by defects are 6%, 11%, and 16%. These values reflect the conclusions of the Indiana study and seem consistent with present conditions in Virginia. The values for the societal costs of accidents are in the two sets, A and B, shown in Table 7. These estimates reflect the values derived in the NSC and the NHTSA studies. The values for the level of program effectiveness are 12%, 40%, and 64% for the annual program and 16%, 50%, and 80% for the semiannual program. The differences in effectiveness reflect the differences in the mechanical condition of the vehicles reported in the studies reviewed.

The upper-left portion of Table 12 displays the benefit-cost ratios for a semiannual program assuming the lower set of values (Set A) for the societal costs of accidents. The most striking feature of this portion is that even over a wide range of varying estimates, six out of nine ratios are less than one. A figure less than one means that costs of the program exceed its estimated benefits. If the higher set of values (Set B) for the societal costs of accidents is used (the lower-left portion of the table), only four out of nine ratios are less than one. In these two portions, it can be seen that when the level of program effectiveness is 16%, benefits do not exceed costs over the entire range of estimates for the percentages of accidents shown. However, this level of program effectiveness would probably be surpassed. At the more realistic 50% level of effectiveness, three of the six ratios are greater than one.

In sum, the semiannual program has a better chance of being cost-beneficial as both the level of program effectiveness and the percentage of defect-caused accidents increase. Some research has indicated that 75% is the maximum level of effectiveness obtainable. For the semiannual program to be cost-beneficial, the values for each of these parameters must be in the upper portion of the range of estimates established.

The benefit-cost ratios for the annual inspection program are shown on the right-hand side of Table 12. For both the A and B figures, at an effectiveness level of 12%, costs exceed benefits over the entire range of estimates for the percentages of accidents caused by defects. Once the level of program effectiveness exceeds 40%, the benefits derived from an annual program will probably exceed the costs of the program.

By comparing all the ratios shown for the two types of programs, it can be seen that the benefit-cost ratios for the annual inspection program are larger than the corresponding ratios for the semiannual program. Therefore, the annual inspection program would be more cost-beneficial.

The fact that the annual program is more cost-beneficial does not mean it is necessarily the best program for Virginia. There are many conceptual and theoretical problems with measuring benefits in terms of lives saved and injuries prevented. For this reason, no important decision should be based solely on the results of a benefit-cost analysis. Also, as long as the benefits from the semiannual program exceed its costs, legislators may not want to risk instituting an annual program. Also, the numbers used in this analysis are only rough estimates at best. One encounters complex valuation problems in trying to estimate the important factors in a PMVI study. The level

TABLE 12

Benefit-Cost Ratios

Semiannual A

% Defect Caused	Effectiveness		
	16%	50%	80%
6.0	0.14	0.43	0.68
11.0	0.25	0.78	1.26
16.0	0.37	1.14	1.83

Semiannual B

% Defect Caused	Effectiveness		
	16%	50%	80%
6.0	0.22	0.68	1.09
11.0	0.40	1.25	2.01
16.0	0.58	1.83	2.92

Annual A

% Defect Caused	Effectiveness		
	12%	40%	64%
6.0	0.20	0.67	1.08
11.0	0.37	1.24	1.98
16.0	0.54	1.80	2.88

Annual B

% Defect Caused	Effectiveness		
	12%	40%	64%
6.0	0.32	1.08	1.73
11.0	0.59	1.98	3.16
16.0	0.86	2.88	4.60

of program effectiveness is an especially elusive figure.
Finally, since there are very few data on the Virginia
semiannual inspection program, the assumptions in this
analysis were based on the literature which evaluated
systems in other states. It is difficult to ascertain how
they apply to present conditions in Virginia. The results
of many of the studies depend on the frequency of inspec-
tion, the enforcement of inspection standards, and regula-
tion of the system. Increasing the enforcement of in-
spection standards should lead to an increase in the quality
of inspections and, therefore, an increase in program
·effectiveness. According to Frank Grenier of the Motor
Vehicle Programs Division of the NHTSA, the inspection
program in Virginia is one of the best administered pro-
grams in the country. He also feels that an inspection
program is only as good as its administration and enforce-
ment. For these reasons, the program in Virginia is likely
to be more effective in reducing accidents than the programs
in states with less regulation. These possible differences
between the programs dealt with in the literature and
Virginia's inspection program should be considered when
making a decision on the basis of the present analysis.

Another important limitation of the present benefit-
cost analysis was its scope. It examined two types of
PMVI programs: an annual inspection program and a semi-
annual program. These are not the only viable alternatives.
In a complete study one should examine the possibilities
of instituting a random motor vehicle inspection program
or having no inspection program at all. In addition,
motor vehicle inspection should be compared with other
highway safety programs, such as alcohol and driver
training programs, in benefit-cost terms. By conducting
such a complete study, highway safety funds can be put to
most beneficial use. All of these limitations in the bene-
fit-cost analysis, plus the conclusions of the literature
review, must be carefully considered before a decision
can be reached.

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