FINAL REPORT

EFFECTS OF THE ENERGY CRISIS ON TRAFFIC CRASHES IN VIRGINIA

by

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and

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ABSTRACT

A number of energy crisis related factors were examined to determine if a change in energy crisis variables occurred during the 1973-74 shortage and if this change could be related to changes in the accident environment in Virginia. The variables examined in the study included mean speed, speed distribution, travel, vehicle mix, visibility (daylight saving time), occupancy rates, and other non-energy crisis factors such as restraint usage. Mean speeds were found to be related to accident severity while speed distributions were found to relate to accident causation. The relationship between travel and accident causation in Virginia was not found to be as strong as had been indicated in previous studies. Changes in vehicle mix supported the notion that an increased dispersion in vehicle size and age during the energy crisis would tend to worsen the accident environment. Reduced morning visibility due to the temporary use of daylight saving time did not increase fatalities, while changes in occupancy rates and restraint usage were too gradual to account for much of the reduction in accidents during the energy crisis.

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INTRODUCTION

In the summer of 1973, American motorists began to hear about, and in some cases experience, the effects of a shortage of petroleum and petroleum products. With the initiation of the Arab oil embargo after the October 1973 Middle East War, the petroleum shortfall became an "energy crisis" and most Americans found a significant change in their lifestyles.

The most dramatic impact of the energy crisis was felt in the transportation system, because of the decreased availability of motor vehicle fuels. Accordingly, former President Nixon requested that measures aimed at economy and efficiency be introduced to conserve fuel and to ensure the continued operation of the highway transportation system.

As a result, on November 26, 1973, the Honorable Linwood Holton, then Governor of Virginia, issued an Executive Order that reduced the maximum speed limit in Virginia from 70 to 55 miles per hour. This action was followed by the introduction and subsequent passage of House Bill 11372, the Emergency Highway Energy Conservation Act, which established the 55 miles per hour limit nationwide. Congress then enacted a bill putting the country on daylight saving time effective January 6, 1974, and later Governor Mills Godwin of Virginia issued an Executive Order setting up the odd-even gasoline distribution plan, later rescinded, to be effective February 20, 1974. Finally, the Federal Aid Highway Amendments of 1974 included the provision that in order for a state to receive approval for Federal Aid Highway funds, it must continue the use of a 55 mph speed limit.(1) These specific events and many others resulting from the energy shortage placed highway safety personnel in a position of trying to answer questions from the public and other Government officials as to the effects of the energy crisis and as to future effects of further fuel shortages on traffic crashes in Virginia. In a quest for answers, John T. Hanna, Director of the Highway Safety Division of Virginia, requested the Safety Section of the Virginia Highway & Transportation Research Council to initiate a study into the highway safety related effects of the energy crisis.(2)

PURPOSE

The objective of the work reported here was to identify and analyze accident reducing factors associated with the energy crisis. The information to be developed would be used to formulate suggestions for the maintenance and improvement of current safety programs and in the development of long-range safety programs.

METHODOLOGY

The analysis of energy crisis data was conducted in two parts, each part designed to interpret one aspect of Virginia's energy crisis experience as follows:

1. Changes in the Traffic Safety Environment — This part dealt with the overall impact of the energy crisis on accidents in Virginia. It considered both changes in the numbers of accidents as well as changes in the characteristics of accidents. In order to detect these changes accurately, traffic safety indicators for the period in which the effects of the energy crisis were felt were compared with those for the period prior to the energy crisis. In many cases comparisons were made between actual figures and projected figures in an effort to get an accurate picture of changes that occurred. Although comparisons of actual year to year figures are useful, absolute reliance upon them would ignore previous trends. Figure 1 illustrates this point. If 1974 gasoline sales are compared with 1973 sales, there is a decrease of about 200 million gallons. However, given the ascending trend in gasoline sales, one would have expected gasoline sales to increase rather than decrease. Accordingly, the decline in gasoline sales may be viewed as being closer to 400 million gallons.

2. Analysis of Major Factors Responsible for the Changes in the Traffic Safety Environment — The second part of the analysis consisted of the identification and analysis of factors that might explain any changes discovered in the first part. A review of previous studies was conducted to aid in the general discussion of each of the selected factors. Changes in energy crisis variables which were thought to influence accidents were then compared to actual changes in accidents and their severity.

Data for this study were acquired from numerous sources. These include speed data and information on traffic volumes from the Traffic and Safety Division of the Virginia Department of Highways and Transportation, accident data from the Virginia Department of State Police, materials on gasoline consumption and sales from the Virginia Petroleum Industries, and data on vehicle age and mix from R. L. Polk and Company. Information was also abstracted from annually published sources, such as Virginia Crash Facts, Summary of Accident Data, and Traffic Data: Automatic Traffic Recorder Stations.

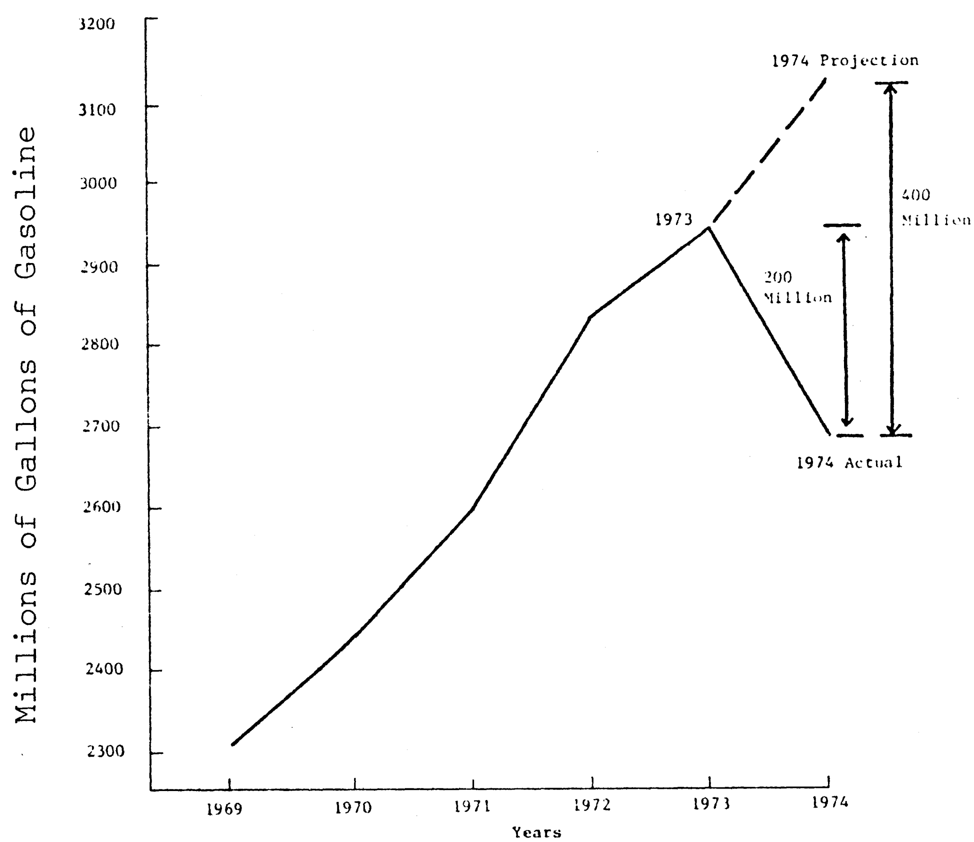

Figure 1. Trends in gasoline sales in Virginia.

ANALYSIS

The "energy crisis" often refers to a four-month period (November 1973 — March 1974) in which gasoline was in short supply, due primarily to the OPEC oil embargo. This period of crisis focused the nation's attention upon the need to conserve energy and upon the possibility of recurring gasoline shortages. With this possibility in mind, reference is often made to a broad energy crisis that continues to exert an influence upon vehicular travel long after the so-called energy crisis. Also in presenting the analysis of the effects of the energy crisis, data for the entire year of 1974 will be used frequently to demonstrate the lasting effect of the energy crisis.

Changes in Traffic Safety Environment

The energy crisis introduced a unique set of circumstances into the traffic safety system in Virginia. The oil embargo touched off a deterioration of available petroleum supplies which the consumer felt most often in terms of long lines and limited purchase policies at service stations, increased gasoline prices, and difficulty in obtaining fuel to heat homes. Nationally, gasoline sales fell well below 1973 levels,[3] as did gasoline sales in Virginia (see Figure 2). As a result of the shortage of fuel and the various conservation measures instituted to deal with the problem, the accident environment of the nation began to change.

It is now evident that the energy crisis prompted changes in characteristics of vehicular travel that have had a positive effect upon the traffic safety environment in both Virginia and the United States. The extent to which we can decide the relative influence of the various energy crisis factors is indeterminable, for it is impossible to quantify all the factors that shape traffic safety. However, it is clear that the energy crisis had a very visible impact upon traffic safety, while the influence of other factors was more subtle.

The most dramatic benefit attributed primarily to the energy crisis is a reduction in highway deaths. In 1973, 54,846 persons were killed in traffic accidents in the U. S. In 1974, there were 45,473 highway deaths, representing a 17% decrease from 1973 (see Table 1). This reduction is even more pronounced when contrasted with the upward trend in national fatalities. The influence of the energy crisis is reflected by the fact that reductions in national traffic fatalities were greatest during the early months of 1974 when the effects of the energy crisis were felt most heavily.

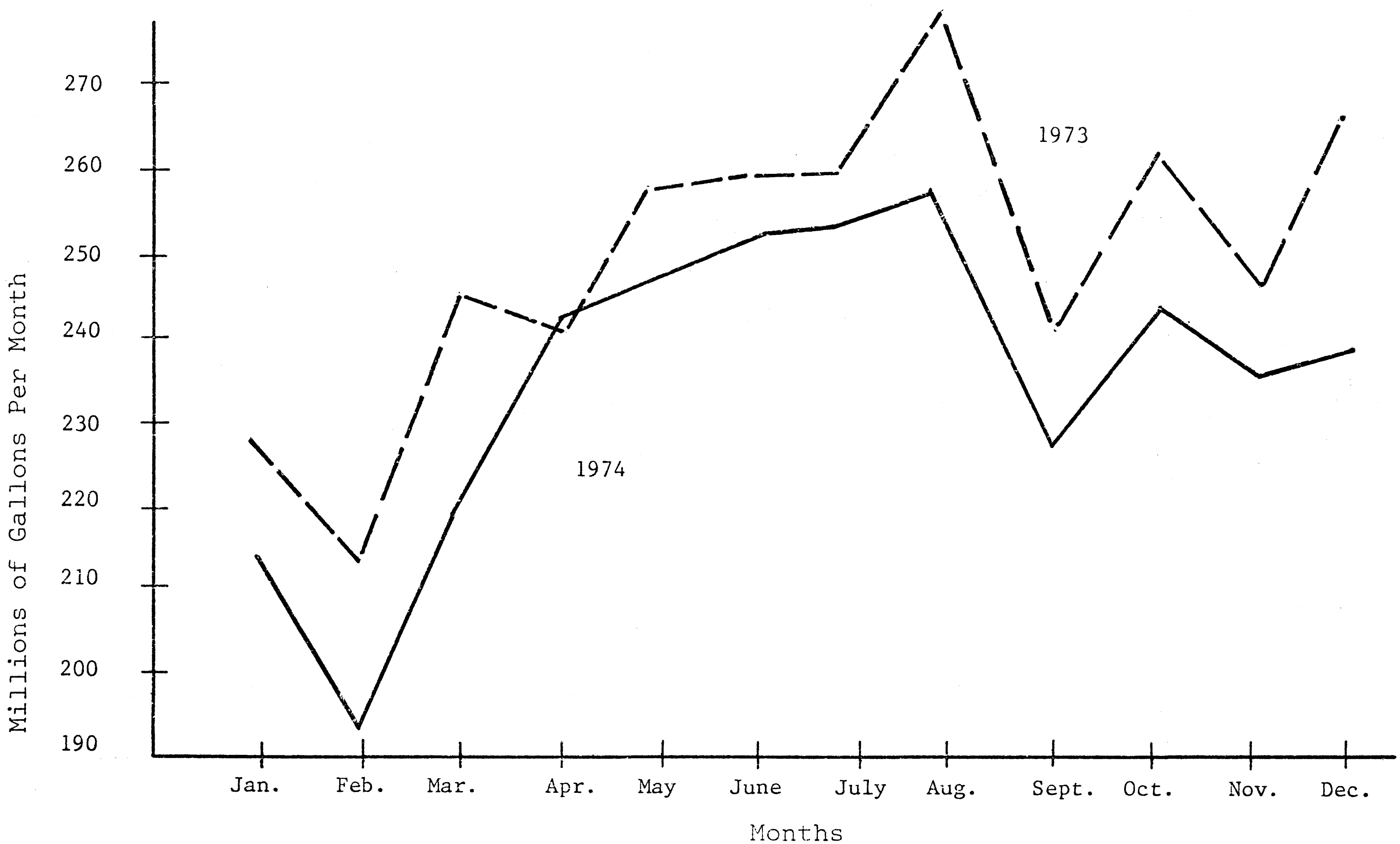

Figure 2. Gasoline sales in Virginia. (Source: Virginia Petroleum Industries.)

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As the energy crisis became less severe, traffic fatalities moved closer to 1973 levels, but were still markedly lower than the level expected for 1974.

As shown in Table 2, Virginia also experienced a marked decline in fatalities, although these smaller statewide figures are much more variable across time. Highway deaths were 13.9% lower in 1974 than in 1973, with a reduction from 1,220 fatalities to 1,050 fatalities. This marked the first time since 1966 that the fatality level in Virginia fell below 1,200.

Fatal accidents in Virginia were 12.6% lower in 1974 than in 1973. This figure was significantly lower than the projected level (see Table 3). Decreases in injury accidents (6.5%) and property damage only accidents (8.8%) were also experienced. Since both injury and property damage only accidents had been steadily increasing for several years, the 1974 levels were also significantly lower than projected.

Table 1

Estimated National Traffic Fatalities and Changes(4)

Month	1973	1974	Percent Change
January	3,834	2,950	-23.1
February	3,479	2,625	-24.5
March	4,328	3,192	-26.2
April	4,454	3,442	-22.7
May	4,813	3,732	-22.5
June	5,135	4,141	-19.4
July	5,156	4,320	-16.2
August	5,227	4,537	-13.2
September	4,899	4,190	-14.5
October	5,203	4,371	-16.0
November	4,410	4,115	- 6.7
December	3,908	3,858	- 1.3
Total	54,846	45,473	-17.09

Table 2

Virginia Traffic Fatalities and Changes

Month	1973	1974	Percent Change
January	77	79	+ 2.6
February	90	51	-43.3
March	91	97	+ 6.6
April	97	74	-23.7
May	122	67	-45.1
June	131	97	-26.0
July	109	124	+13.8
August	96	101	+ 5.2
September	128	82	-35.9
October	93	101	+ 8.6
November	96	84	-12.5
December	90	93	+ 3.3
Total	1,220	1,050	-13.9

Table 3

Accident Data for 1974 and Prior 5-Yr. Period

Year	Fatal Accidents	Injury Accidents	Property Damage Only Accidents
1969	1,117	31,846	98,636
1970	1,066	32,296	103,561
1971	1,054	33,577	109,776
1972	1,100	35,600	118,557
1973	1,048	35,070	120,519
1974	916	33,715	109,900
Projected 1974	1,046	37,403	127,838

Not only did the numbers of fatal accidents change, but also the distribution of accidents among the three accident categories (fatal, injury, and property damage only) shifted significantly ($p < .001$) during the energy crisis. A smaller proportion of accidents fell into the fatal and property damage only categories, with a corresponding increase in the proportion of accidents in the injury category. Within the injury category, the distribution of the severity of injuries changed significantly between 1973 and 1974 ($p < .001$). In 1974 a smaller proportion of injuries fell into the two most severe categories, while a larger proportion fell into the least severe category. This shift was also found in several other states,[5,6,7] which indicated that the energy crisis contributed to making accidents less serious.

Rates for all three accident classifications declined in almost all geographic areas in 1974. In most areas the declines were either contrary to previous trends or were greater than expected. The accident rate (number of accidents/100 million miles of travel) declined on interstate, primary and secondary roads) (see Figure 3). The injury rate (injuries/100 million miles of travel) also declined on all three road types (see Figure 4). The death rate (deaths/100 million miles of travel) declined sharply on interstate and secondary roads, but increased on primary roads (see Figure 5).

The lasting effect of the energy crisis is illustrated by comparing preceding and succeeding time periods. Between December 1, 1972, and May 31, 1973, there were 595 traffic fatalities in Virginia. Between December 1, 1975, and May 31, 1976, there were 452 fatalities. Thus, in the period after the energy crisis traffic fatalities were 24% lower than in the period before the energy crisis. This sharp decrease contrasts with the narrow range within which fatalities rose in the five-year period prior to the energy crisis (1,218 deaths/year - 1,304 deaths/year). The lasting change in the traffic safety environment is also evidenced by national data. For example, fatalities in May 1976 were more than 18% below the death total for the same month in 1973.

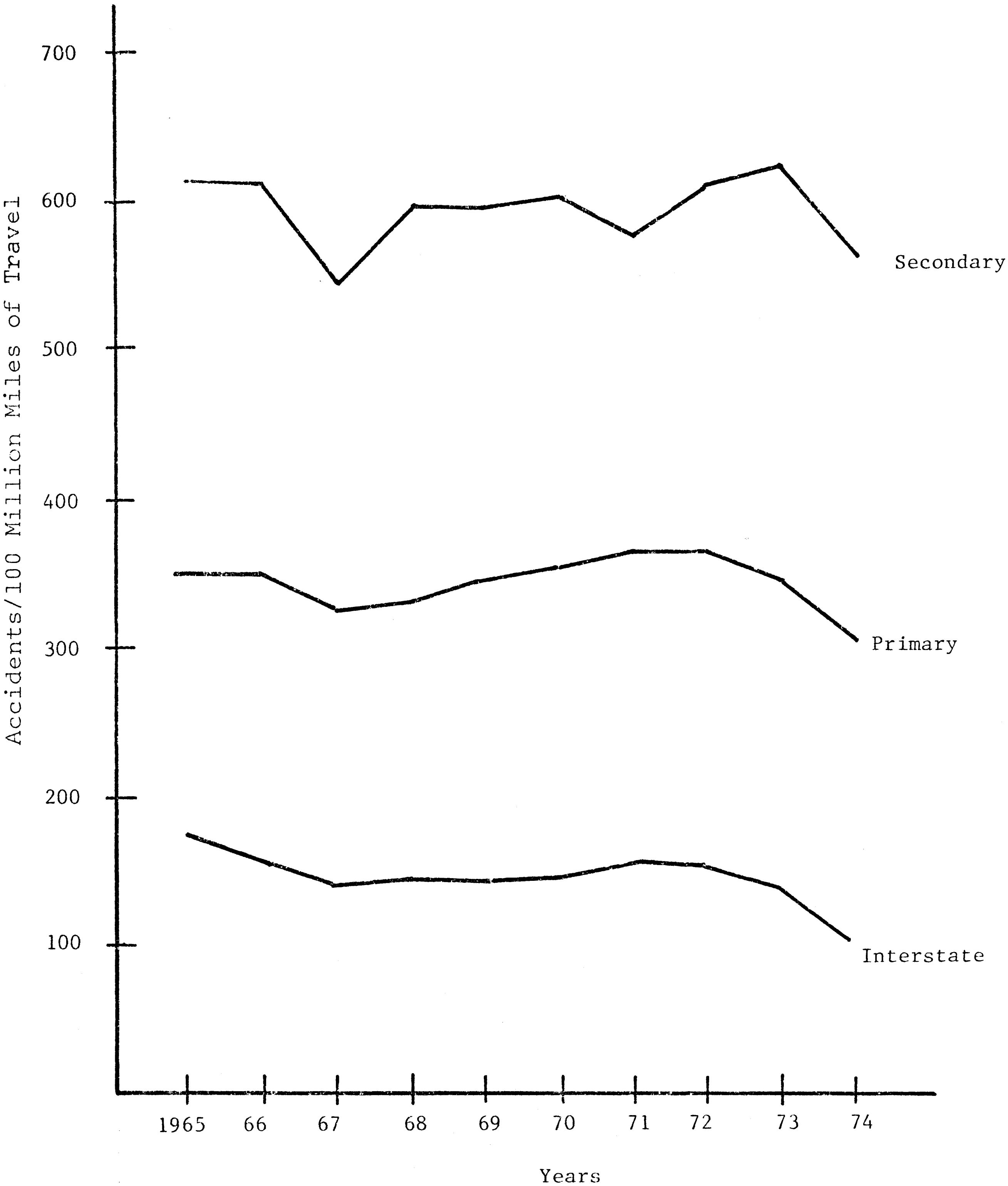

Figure 3. Accident rates by roadway type in Virginia.

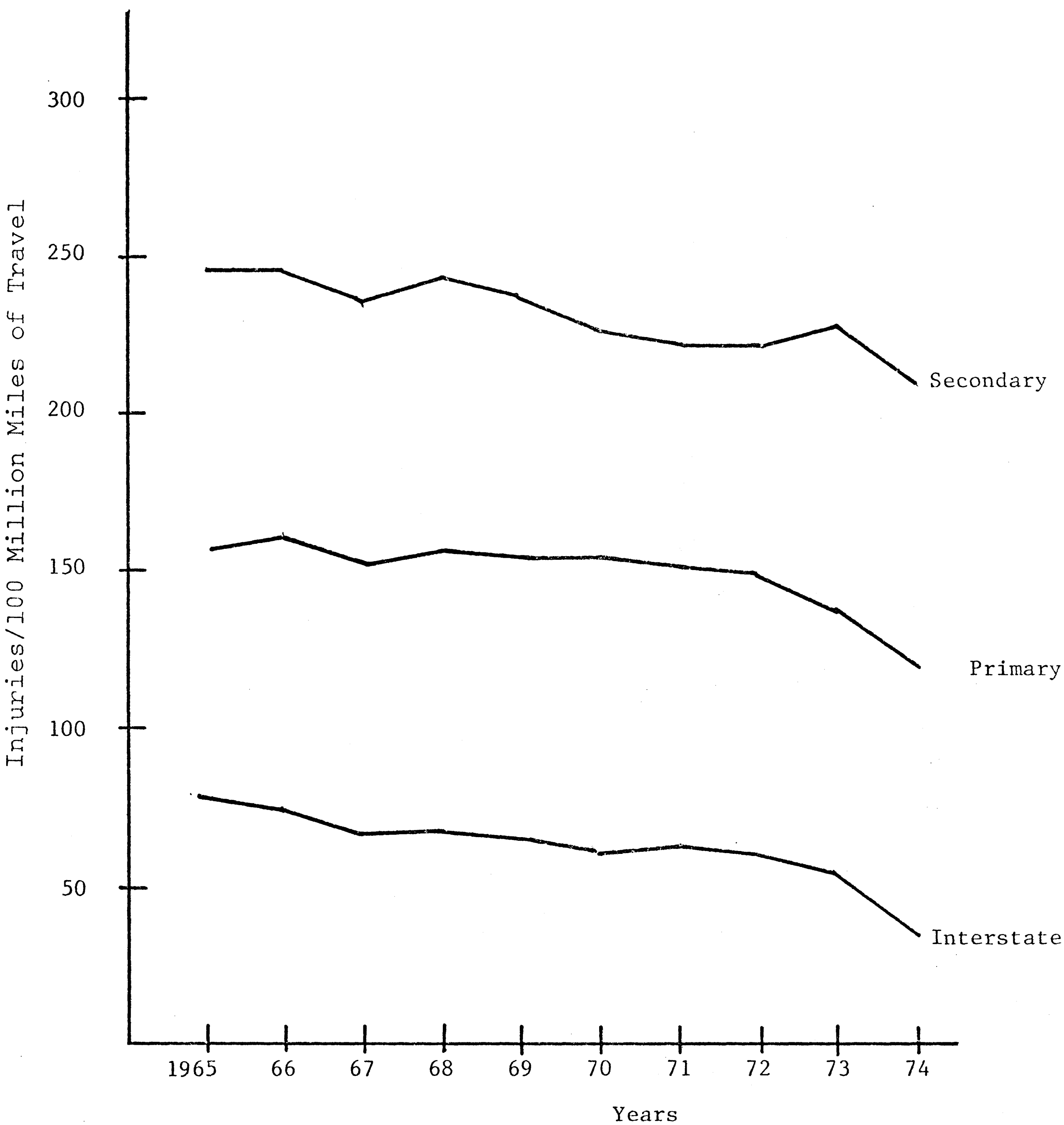

Figure 4. Injury rates by roadway type in Virginia.

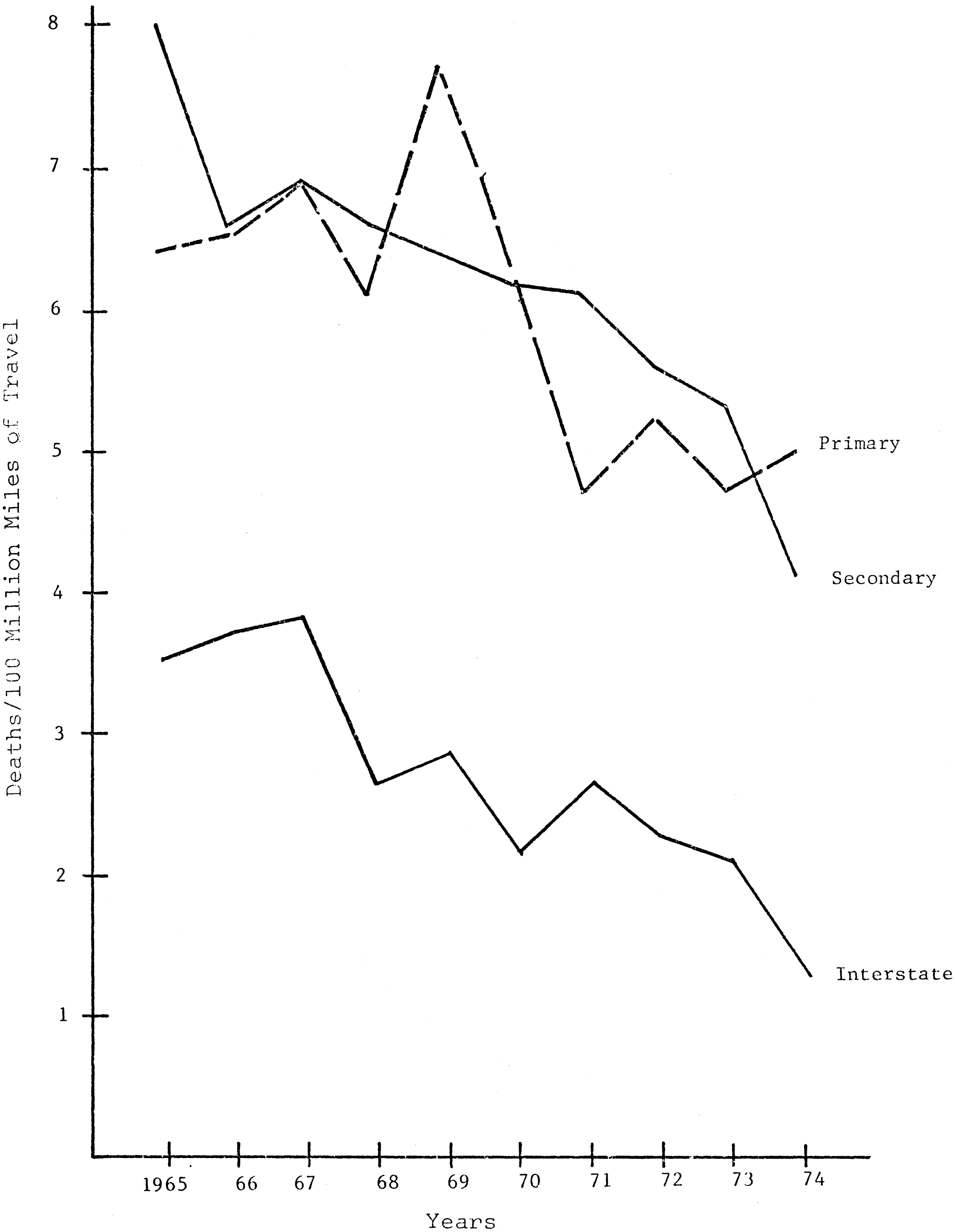

Figure 5. Death rates by roadway type in Virginia.

Analysis of Major Factors Responsible for Changes in the Traffic Safety Environment

During the energy crisis motorists traveled at lower speeds due to reduced speed limits and a desire to use less gasoline. Lower traveling speeds are frequently cited as a major factor in accident reduction. Although speed is certainly an important factor in traffic safety, W. W. Rankin of the Highway Users Federation warns that

> too much emphasis on the speed factor alone precludes a full understanding of the complex relationships in travel habits that have brought about the accident reduction since November 1973. Lack of understanding of these relationships could make more difficult an effective application of the current experience to development of long-term traffic safety programs.(8)

Accordingly, other factors must be considered to fully explain the reduction in accidents.

The energy crisis factors chosen for analysis in this study were selected after a review of a number of previous studies. Factors were chosen only if there was supporting evidence that they could influence accident patterns. The factors examined in this study were (1) traveling speed, (2) speed distribution, (3) traffic volume, (4) daylight saving time, (5) vehicle mix, (6) vehicle occupancy rates, and (7) safety belt usage.

Traveling Speed

Much attention has been given to slower traveling speeds resulting from the 55 mph speed limit and the possible impact that speed reductions may have on accidents. The impact of speed reduction can best be analyzed if the accident is divided into the pre-accident period, accident occurrence period, and post-accident period.

It is generally recognized that during the pre-accident period high speeds reduce stopping and maneuvering capabilities, and magnify tire and headlight limitations, road design inadequacies, driver skill deficiencies, and the effect of alcohol.(9) Since high speeds reduce accident avoidance capabilities, one may expect them to result in more accidents. However, several studies have indicated that there is no direct relationship between speed and the total number of accidents. In fact, "in many speed zones [in California] where speed limits have been raised the total accident rate has actually fallen."(10)

This reduction in accident rates where speeds have increased indicates that slower speeds will not necessarily result in fewer accidents. Since it is known that increased speed reduces accident avoidance capabilities, the reduction in accidents where speeds had increased confirms the contention that factors other than speed have an important impact on accidents.

During the accident occurrence period high speeds present serious consequences. Accident severity has been found to be directly related to high speed in several studies.(10) The consequences of high speeds are mathematically evident. "For every doubling of a vehicle's velocity, its kinetic energy is quadrupled. This energy will be turned against the vehicle and its occupants in the event of a crash with a solid object. The implications of this physical formula $K.E. = 1/2\ MV^2$ are particularly ominous in the higher ranges of highway speed."(9)

The post-accident period is also adversely affected by high speeds. Fast speeds heighten the possibility of fire following a crash, contribute to the degree of severity of the wreckage, and increase the difficulty, time, and hazard involved in extricating injured occupants.(11)

Thus, while absolute speed does not directly relate to accident causation, it does relate to the consequences of a particular crash in terms of property damage, personal injuries and fatalities.(12,13,14,15) One expected outcome of the energy shortage which would be attributable to traveling speed might be a reduction in the severity of accidents rather than reductions in the numbers of accidents occurring.

The impact of the 55 mph speed limit on traveling speeds in Virginia is depicted in Figure 6. Three groups of roadways were established according to the amount of change in their speed limits that occurred as a result of the national 55 mph speed limit. The three groups are: (1) roadways where speed limits decreased 15 mph (Interstate Routes 64, 66, and 95), (2) roadways where speed limits dropped 5 mph (U. S. Routes 29/211 and 360), and (3) roadways where no speed limit change occurred (U. S. Routes 250, 60 and 1). Linear regression analysis was applied to speeds on each roadway group to determine the predicted levels of speed for 1974.

Prior to the energy crisis, average speeds on roadways where a 15 mph speed limit change occurred increased gradually from 59.7 to 69.3 mph. When the energy shortage occurred, speeds dropped sharply to 57.1 mph. Although there was some recovery in average speeds in the months that followed, at the end of 1974 speeds were considerably lower than the projected levels.

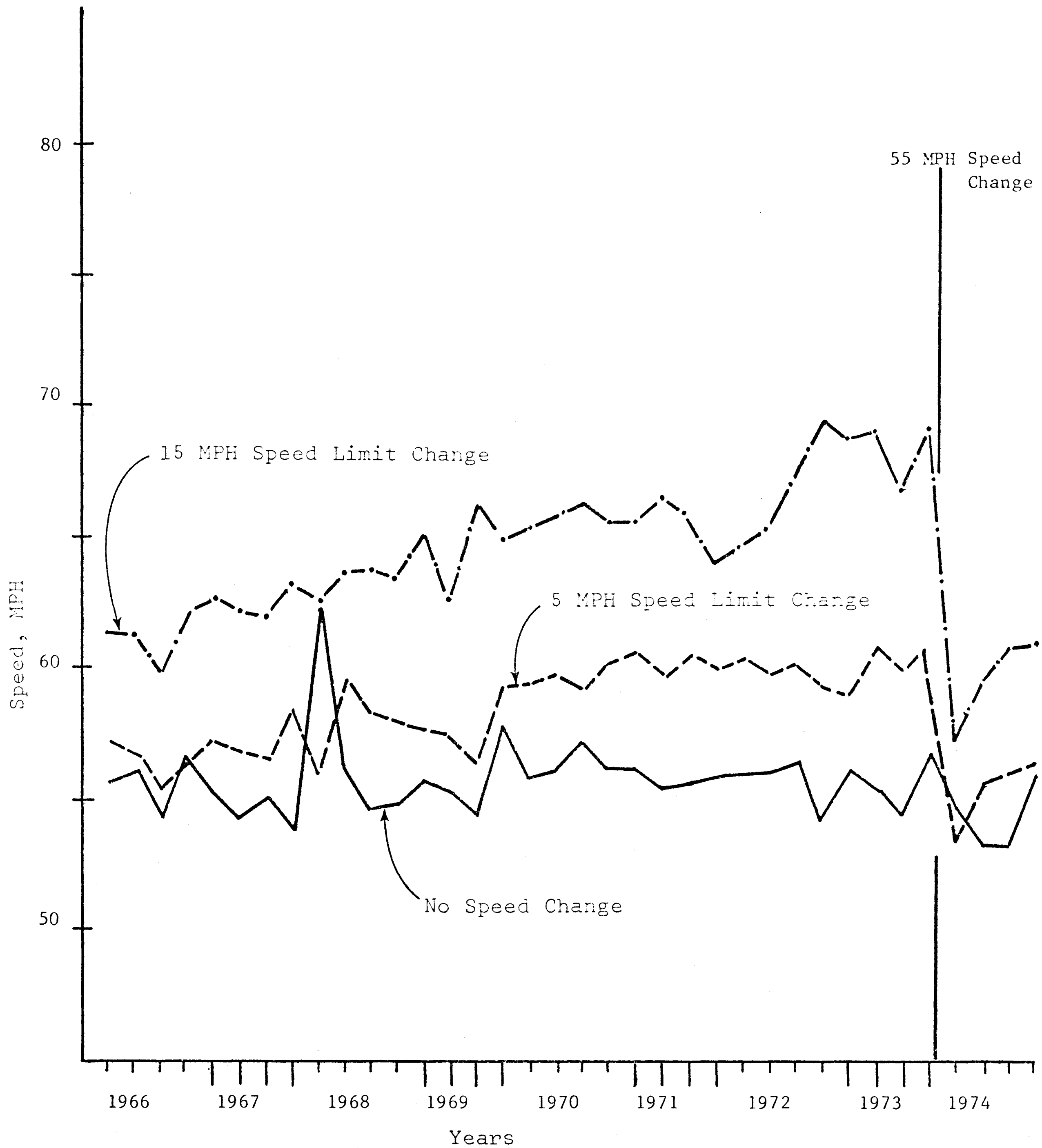

Figure 6. Average traveled speeds on selected Virginia roadways.

Average speeds on highways which had a 5 mph speed limit decrease also exhibited an ascending, linear trend prior to the energy crisis, ranging between 55.3 and 60.7 mph. During the energy crisis, average speeds on these roadways dropped to 53.5 mph and gradually recovered to 56.4 mph by the end of 1974. Initially, the decreases in average speed exceeded the 5 mph change in limit and were significantly different from levels expected had the energy crisis not occurred. However, by the end of 1974 the average speed had recovered to a level which was not significantly different from predicted levels, although the level was lower than pre-energy crisis speeds.

On roadways where there was no speed limit change average speeds exhibited a linear trend and ranged between 53.9 and 57.7 mph, with one deviation. During 1974 the average speed declined to 53 mph and then recovered to 55 mph. Although the average speeds for 1974 were lower than previous speeds, they were not significantly lower than predicted levels.

Thus, average speeds did decrease in Virginia, as in many other states, as a result of the energy crisis.[16,17,18] One benefit to be expected from this decrease in average speed is a reduction in accident severity. On roadways where speed limits were reduced by 15 mph and the average traveling speed declined markedly, the distribution of accident severity changed significantly in 1974 (see Table 4). Prior to the energy crisis 35.6% of all crashes on roads where a 15 mph speed limit change occurred were injury crashes. However, during 1974 this percentage was reduced to 23.2%, with a corresponding increase in the property damage only category. This finding indicates that of those people involved in accidents, smaller percentages were injured during the energy crisis than in the period before the energy crisis.

On roadways where speed limits decreased 5 mph or remained the same, the percentages of injury and fatal accidents decreased slightly. However, these changes were not statistically significant, which indicates that the changes may have occurred due to chance factors alone.

Accident severity was also analyzed by comparing actual and predicted injury/fatality ratios for the three groups of roadways (see Table 5). The number of injuries per fatality is frequently used as an index of accident severity. As the ratio increases, a greater proportion of people are injured rather than being killed an indication that accidents are less severe. On roadways where 15 mph and 5 mph speed limit reductions occurred the injury/fatality ratio increased, indicating less severe accidents.

Table 4

Crash Severity Distribution by Speed Limit Change, In Percent

Speed Limit Change / Crash Severity	15 MPH		5 MPH		Unchanged	
	5-Yr. Mean Prior to Energy Crisis	1974	5-Yr. Mean Prior to Energy Crisis	1974	5-Yr. Mean Prior to Energy Crisis	1974
Fatal	1.5	1.2	1.6	1.1	1.3	1.1
Injury	35.6	23.2	36.9	35.0	35.0	34.2
Property Damage Only	62.9	75.6	61.5	63.4	63.6	64.7
Total	100.0	100.0	100.0	99.5	99.9	100.0

However, only the increase on the roads where the speed limit dropped 5 mph was statistically significant. On roads where there was no change in speed limits the injury/fatality ratio decreased, but this change was not statistically significant.

Changes in accident severity were also found for the state roadway system as a whole. A comparison of actual injury figures for 1974 with linear projections for 1974 revealed that there were significantly fewer serious and slight injuries than predicted (see Table 6). It was also found that actual and projected distributions of injury severity were significantly different from one another ($\chi^2 = 135.29$, $p < .01$).

Table 5

Injury/Fatality Ratios in Virginia, 1974

Roadway Classification	Projected Ratio	Actual Ratio
15 mph Speed Limit Decrease	27.27	30.04
5 mph Speed Limit Decrease	18.44	38.99
No Speed Limit Change	33.59	30.18

Table 6

Injury Distributions in Virginia, 1974

	Projected		Actual		Actual Difference From Projected
	Number	Percent	Number	Percent	
Seriously Injured	33,158	66.23	29,638	65.88	Yes
Slightly Injured	6,760	13.50	5,182	11.52	Yes
Complaint of Pain	10,148	20.27	10,171	22.60	No
Totals	50,066	100.0	44,991	100.0	Yes

The difference between the actual and projected figures can also be analyzed in terms of the speeds at which accidents occurred. This approach was taken in an effort to better explain why the 1974 accident levels were lower than they were predicted to be. Over 55% of the difference between predicted and actual fatal accidents is attributable to fewer fatal accidents occurring at speeds in excess of 55 mph (see Table 7). This reduction in high speed fatalities is consistent with the findings of reduced average traveling speeds and reduced accident severity. It also indicates that many motorists who would have been killed in high speed accidents benefited from the energy crisis when they slowed down.

About 33% of the reduction in fatal accidents occurred at speeds of less than 35 mph. Since this speed represents largely urban driving, it is apparent that urban drivers benefited from the energy crisis, but not as much as did the higher speed travelers. In the 50-55 mph range, fatal accidents were slightly higher than predicted. This is not surprising, since the 55 mph speed limit forced many more motorists to drive in that range.

The lower accident figures for 1974 can also be analyzed in terms of adherence to speed limits. Over 60% of the difference in fatal accidents was attributable to a reduction of fatal accidents by motorists who were adhering to speed limits (see Table 8). Since the 55 mph speed limit was in effect throughout most of 1974, it appears that the reduction to 55 mph provided a safer speed limit.

In the injury accident category and the all accident category large proportions of the variance from predicted levels were attributable to motorists who adhered to speed limits. Those who did not adhere to speed limits accounted for only a small part of the difference from predicted figures.

Table 7

Percent Difference in Accidents by Estimated Speeds Prior to Accident, 1974

Speed Category	Fatal Accidents	Injury Accidents	All Accidents
0 - 15 mph	-15.81	-34.52	-45.44
16 - 35 mph	-16.84	-22.27	-19.52
36 - 50 mph	-11.91	-13.75	- 9.54
50 - 55 mph	+ 2.89	+ 1.22	+ 0.15
55 and above	-55.44	-31.53	-17.92
Not Stated	- 2.89	+ 0.84	- 7.72
Total	100.0	100.0	100.0

Table 8

Percent Difference in Accidents by Speed Category (Based on Estimated Speed Prior to Accident,1974)

Speed Category	Percent of Difference		
	Fatal Accidents	Injury Accidents	All Accidents
Exceeded Speed Limit	-10.07	+ 1.02	- 0.54
Exceeded Safe Speed	-22.88	-12.28	- 7.72
No Speed Violation	-60.11	-86.80	-80.35
Not Stated	- 6.93	- 1.93	-11.39
Total Difference	100.0	100.0	100.0

Speed Distribution

Speed distribution is a pattern of driving behavior for motorists as a whole. It represents a combination of the various speeds at which motorists travel and the percentage of motorists traveling at each speed. Figure 7 illustrates four types of speed distribution curves. Graph A represents a symmetric speed distribution, while graph B is illustrative of a speed distribution that is skewed (lopsided). It has been shown that there are fewer accidents on roadways where the speed distribution of traffic is symmetric rather than skewed.[8,19] Accordingly, graph A represents a safer driving environment than does graph B.

Graphs C and D represent speed distributions with low and high variations. In graph C more vehicles are traveling at about the same speed, while in graph D vehicles are traveling at widely differing speeds. It has been found that the lower the variation, or the "tighter" the curve (graph C), for a given roadway, the less chance there is that an accident will occur.[20]

It is also known that accident rates are higher at speeds significantly higher or lower than the mean speed.[21] One study revealed that when speeds were 20 mph higher or lower than the mean, the accident rate was three to eight times higher than the accident rate at the mean.[22] In a different study conducted by the Research Triangle Institute, at variations of +15 mph, this factor was found to be 6 to 21 times higher.[20] Accordingly, one would expect more accidents if there was a wide variation in traveling speeds (graph D).

In order to see how these findings relate to the situation in Virginia and the nation during the energy crisis, actual speed curves were plotted, first for the nation as a whole and then specifically for Virginia roadways. Figure 8 shows the national speed curves for 1973 and 1974. The 1974 speed distribution is tighter and more normally shaped than the curve for 1973. This would indicate that, on the basis of speed data alone, 1974 driving conditions were safer than those in 1973, which has been illustrated by the reductions in accidents and fatalities experienced during 1974.[23,24,25] Virginia speed curves and curves for other states were similar to national ones.

During the energy crisis speed distributions on interstate highways in Virginia shifted markedly. Speed distribution was more symmetric and tighter during the energy crisis than before the energy crisis (in Figure 9 I-64 is presented as representative of the interstate highways in Virginia). A similar shift occurred on primary roads (in Figure 10 Route 360 is presented as representative of the primary roads). However, since speed limits changed only 5 mph on primary roads the shift was not as pronounced. Based upon the findings of the studies on speed distribution cited above, these shifts in speed distribution should contribute to a reduction in accidents.

On roadways where there was no speed limit change, the speed distribution curve shifted only slightly (in Figure 11 Route 60 is presented as representative of secondary roadways). Accordingly, the small shift in speed distribution did little to change the accident environment on secondary roads. In general, it is evident that changes in speed distribution are by-products of reductions in average speeds.

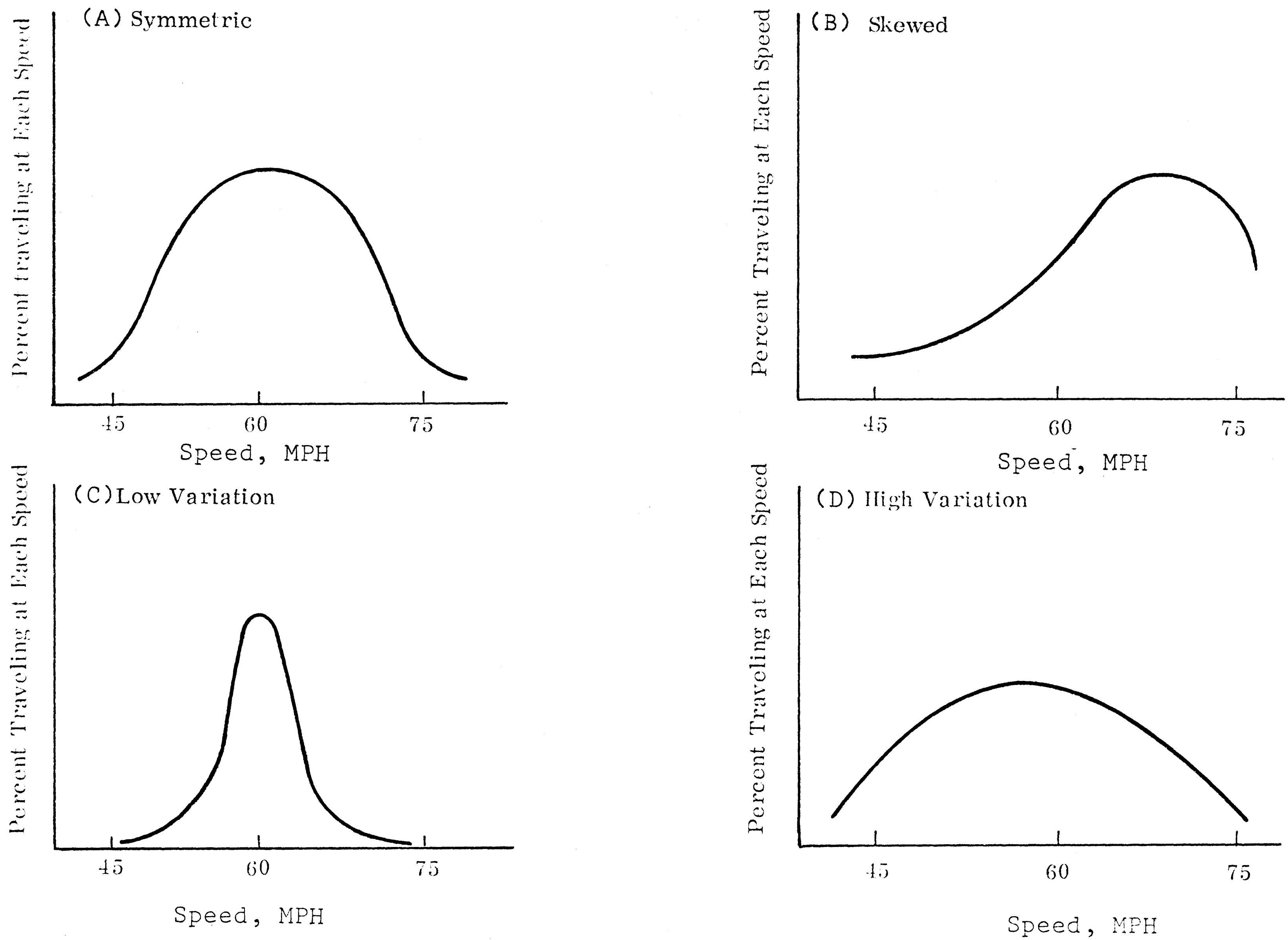

Figure 7. Possible speed distribution curves.

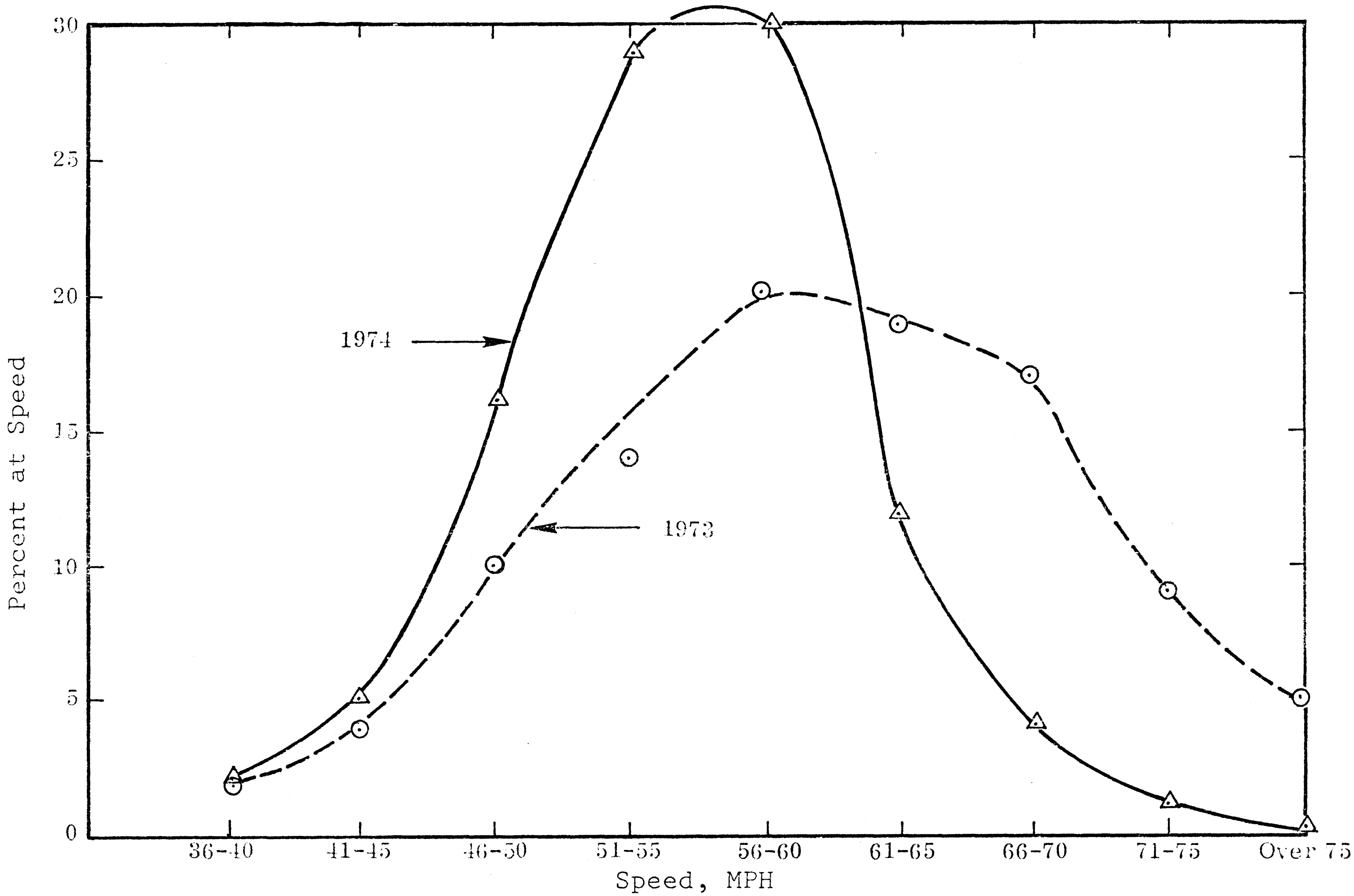

Figure 8. National distribution of vehicle speeds on main rural roads.
(Source: Department of Transportation News, National Highway Traffic Safety Administration, Washington, D. C. December 16, 1974.

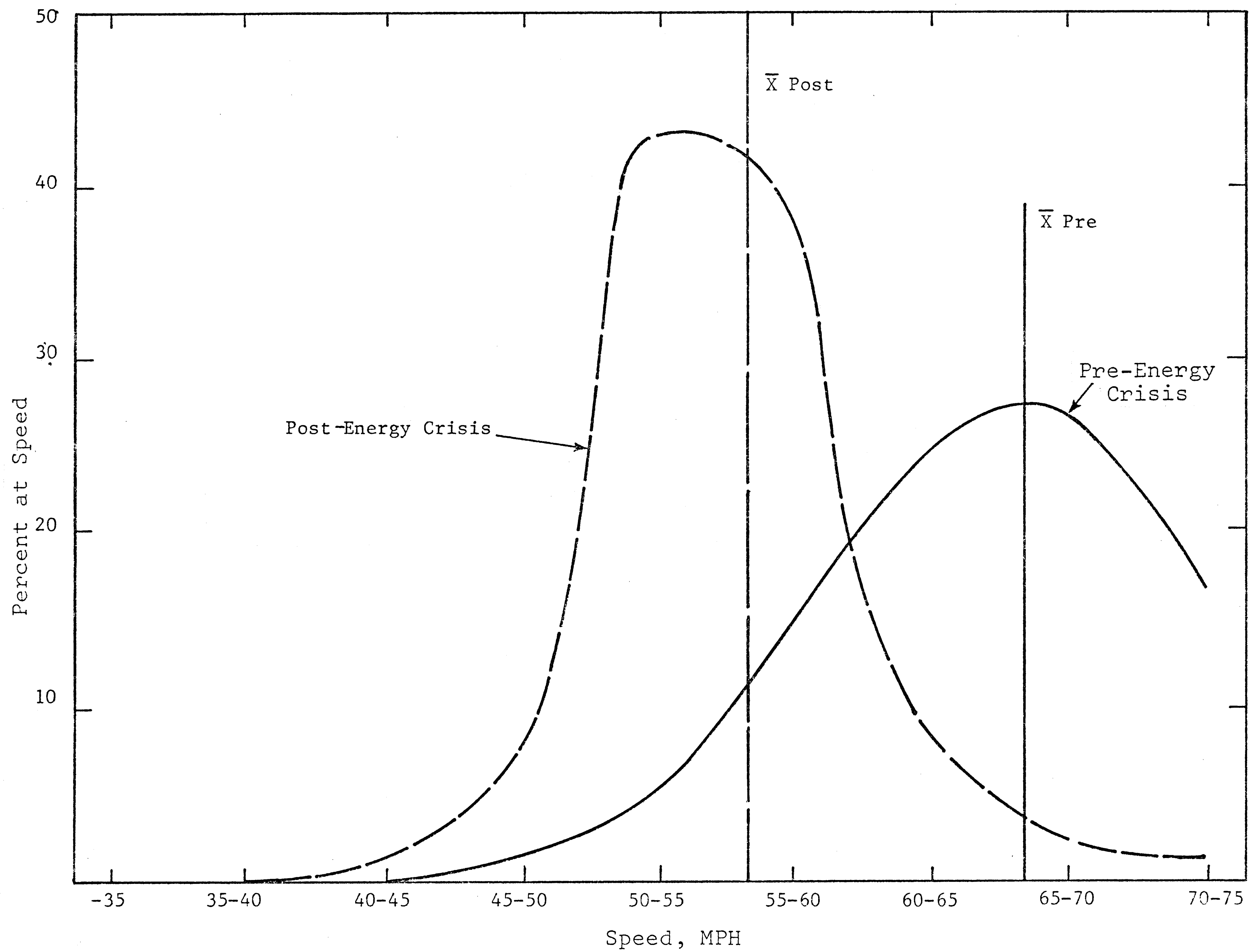

Figure 9. Speed distribution: I-64 winter.

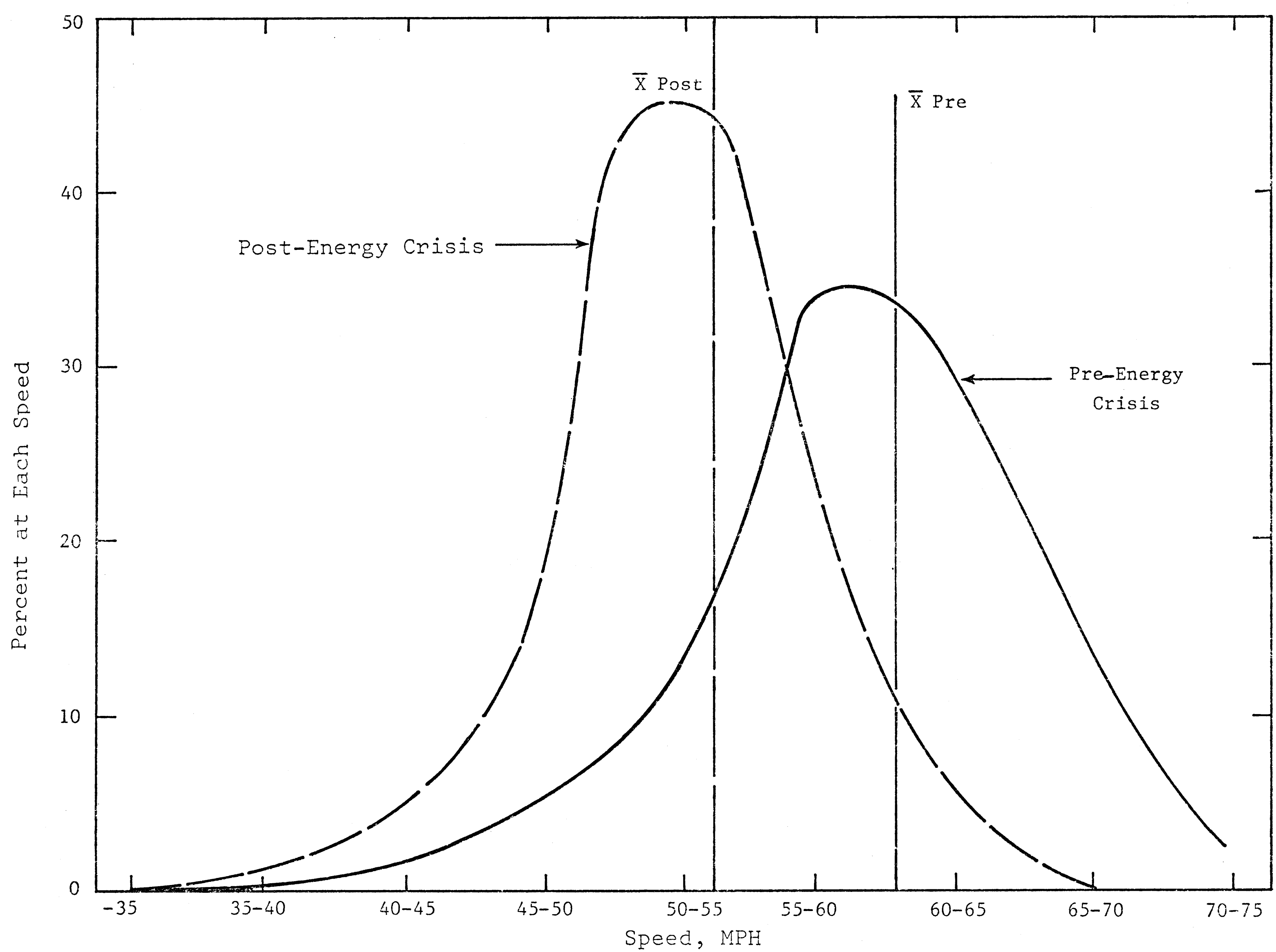

Figure 10. Speed distribution: Route 360 winter.

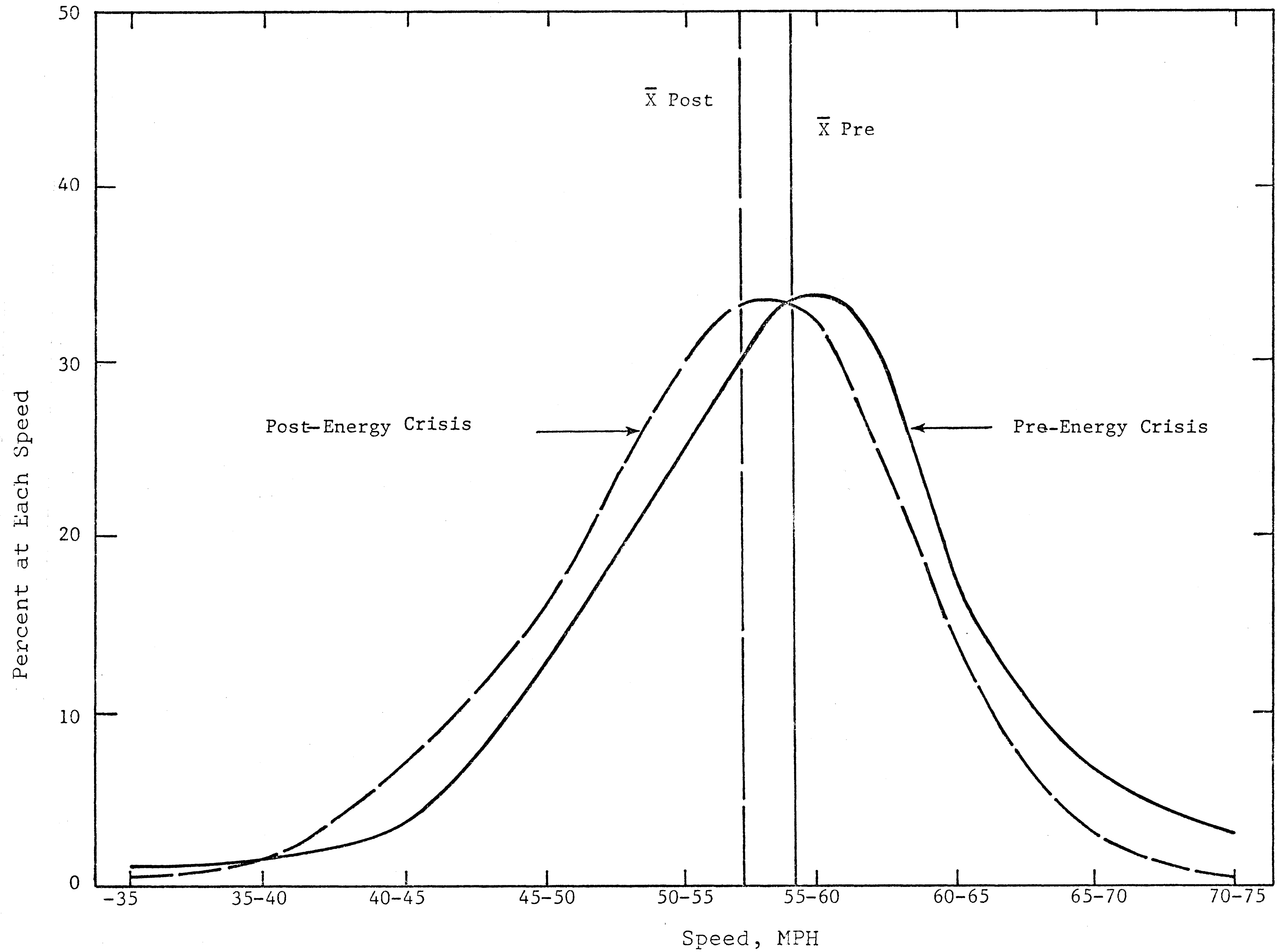

Figure 11. Speed distribution: Route 60 winter.

In summary, the change in the 55 mph speed limit resulted in two separate speed related effects. First, the speeds at which motorists traveled was decreased, which reduced the severity of accidents that occurred. Second, along with the change in traveled speeds, a change occurred in speed distribution, which decreased the number of motorists traveling at extremely high or extremely low rates of speed. This change reduced the probability of accidents occurring.

Traffic Volume

A correlation between accidents and the traffic volume on a given roadway during a certain period of time has long been recognized.(15) As the amount of travel increases the number of accidents increases. Increased travel can be accounted for by two factors: (1) a greater number of cars using the roadway, (2) the same number of cars using the roadway more frequently. In either case it is evident that the chances of an accident would increase with increased travel. In the case of a greater number of cars using the roadway, the increased density of autos would present greater probabilities for an accident.(26) In the case of the same number of cars using the roadway more frequently, drivers would be exposed to the chance of an accident for longer periods of time. Of course, any combination of an increase in density and an increase in frequency would increase travel. These increases in travel would be expected to increase the accident potential exponentially.(27,28)

Prior to the energy crisis, travel (100 million miles of vehicle travel or MVMT) on Virginia roadways had been steadily increasing. In 1974, a marked decrease in travel occurred on interstate highways and primary roads. When compared with projected travel levels for 1974, these decreases were substantial, (see Figure 12). On secondary roads travel increased as expected, in spite of the energy crisis. Given the correlation between travel and accidents, the decreases in travel on interstate and primary roads should contribute to accident reductions.

In order to substantiate the fact that decreases in travel during the energy crisis did result in decreases in accidents, the relationship between accidents and travel must be verified. In order to verify that roads with high traffic volumes should have higher accident experiences than roads with lower traffic volumes, the amount of travel on a given type of road was correlated with its accident experience. A separate correlation was computed for each year so as to eliminate the time variable,* using data like those shown in Table 9.

*It is well known that both the amount of travel and numbers of accidents are highly correlated with time, since each has increased at a similar rate as the years have progressed. This fact produces an artificially high correlation between travel and crashes. For the decrease in volumes resulting from the energy crisis to have an impact on accidents, volume and crashes must be correlated without the artificial correlation with time.

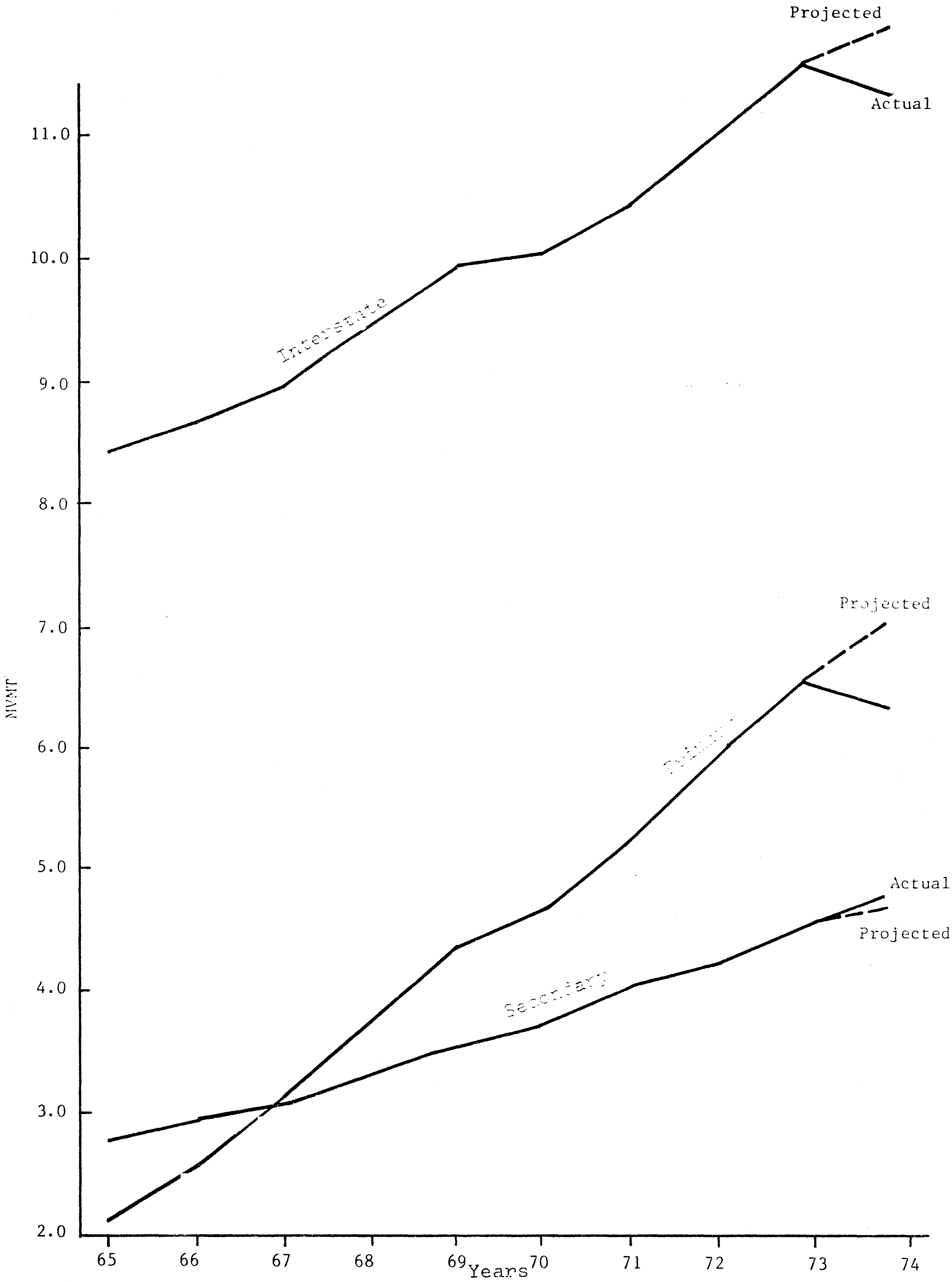

Figure 12. Million vehicle miles of travel by roadway by year.

The results of this analysis are shown in Table 10. On interstates, there is no significant correlation between the amount of travel and any type of crash for any of the four years tested, including 1974. This would indicate that the amount of travel on interstates is not related to numbers of accidents. On arterial and primary roads, fatal crashes seem negatively dependent upon the amount of travel; that is, as volumes go up, the numbers of fatal crashes go down. Otherwise, there is no relationship between the amount of travel and numbers of nonfatal crashes. While the analysis does not completely document the nature of the relationship between MVMT and accidents, it does show that in Virginia the traffic volumes are not as directly related to accidents as was previously thought, and may not have influenced accident experience as much as previously predicted.

Table 9

Data Used in Travel/Accident Correlations, 1971

Average Daily Traffic	Fatal Accidents	Injury Accidents	Total Accidents
1 to 4,999	0	4	13
5,000 to 9,999	28	264	919
10,000 to 14,999	13	227	667
50,000 and above	25	628	2,706
Correlation	-0.03	0.39	0.29

Table 10

Rank Order Correlations Between Million Vehicle Miles of Travel and Numbers of Accidents

Year	Numbers of Crashes		
Interstate			
	Fatal	Injury	Total
1971	-0.03	0.39	0.29
1972	0.03	0.33	0.27
1973	0.07	0.08	-0.18
1974	-0.04	0.12	0.15
Arterial and Primary			
1971	-0.58*	-0.29	-0.22
1972	-0.62*	-0.20	-0.22
1973	-0.63*	-0.21	-0.13
1974	-0.68*	-0.30	-0.21

*Significant at the .01 level.

Although changes in the absolute traffic volumes may not have reduced accidents, it is possible that changes in the characteristics of the traffic could have influenced accident experience. It is well known that some types of trips are more dangerous than others, and a reduction in a particularly hazardous type of trip could reduce accidents and their severity. For instance, one of the most dangerous types of travel involves driving on holiday weekends. According to a National Safety Council study conducted during a five holiday period (1970-1972), travel increased 4%. The resulting increase in fatalities approached 22%. It is logical to assume that reduced holiday traveling could result in greater reductions in fatalities. These reductions could also be applied to other, more dangerous types of driving, such as travel at night or on weekends, pleasure trips, and trips by young drivers, most of which would be expected to decrease during the energy crisis period as compared to commuter trips. The relationship in which a small reduction in a particularly dangerous type of travel results in a larger than expected decrease in accidents could have been particularly beneficial during the energy crisis.

One such change in the distribution of travel was on weekends. On interstate roads, not only was the actual percentage of total driving done on Sunday significantly less than would have been expected had there been no energy crisis, but also the distribution of actual and projected travel was significantly different, with more driving being done on weekdays and less on weekends (see Table 11). Since many pleasure trips, one of the more dangerous types of driving, are taken on weekends, this reduction in weekend driving could have resulted in fewer accidents. On arterial and primary roads, however, no significant changes in this distribution were detected.

Table 11

Distribution of Travel by Day of Week and Roadway Type, 1974

Day	Interstate		Arterial		Primary	
	Actual	Projected	Actual	Projected	Actual	Projected
Sunday	14.02	15.84*	12.80	12.76	11.18	11.75
Monday	13.80	13.31	14.20	13.83**	14.46	14.11
Tuesday	13.15	12.81	13.85	13.98	14.42	14.20
Wednesday	13.90	13.09	14.20	13.97	14.51	14.27
Thursday	14.25	13.44	14.33	14.06	14.83	14.60
Friday	17.02	17.09	16.44	16.14	16.21	16.46
Saturday	13.86	14.41	14.18	14.37	14.40	14.68
$\chi^2 = 18.31$, $p < .01$			NS		NS	

*Actual significantly lower than projected.
**Actual significantly higher than projected.

Another characteristic which changed involved out-of-state travelers. Monthly comparisons between 1973 and 1974 indicate that out-of-state passenger car travel was consistently reduced during the energy crisis and, by as much as 25% in March 1974 (see Table 12). For the entire year of 1974 the percentage of travel by out-of-state cars was significantly lower than projected (see Table 13). These reductions in out-of-state passenger car travel contributed to lower levels of accident occurrence for out-of-state travelers in 1974.

There are other types of selective interactions for which there is no direct exposure information. These include: (1) driving at night — since most recreational and non-work related travel takes place at night, night driving could be expected to decrease during the energy crisis period. A reduction in this particularly dangerous type of driving could result in fewer than expected accidents. (2) Driving by young drivers — since driving by teenagers is usually nonessential travel, this would be among the first types of travel to be reduced. Accident rates among young drivers are especially high, so reduced travel by this group could result in significant accident benefits. (3) Driving by older drivers — members of this group, usually on a budget, could be affected by the rising cost of gasoline and, thus curtail their driving. For this group too the accident rate is high. (4) Driving under the influence of alcohol — a small reduction in this very dangerous type of recreational driving could result in a proportionally larger reduction in accidents. However, it is unlikely that problem drinkers, the group most responsible for serious alcohol related accidents, would curtail their drinking activities.

Table 12

Monthly Travel Comparisons

	Monthly Comparisons (Percent Change)				
	December 1972 to December 1973	January 1973 to January 1974	February 1973 to February 1974	March 1973 to March 1974	April 1973 to April 1974
Travel On					
Interstate, Arterial, Primary Highways	+2.73	- 3.19	- 4.58	- 3.95	-2.82
Travel By					
All passenger cars	+1.92	- 2.89	- 6.68	- 6.10	-4.43
Virginia passenger cars	+2.08	- 1.31	- 4.08	- 3.14	-3.66
Out-of-state passenger cars	+0.90	-10.66	-19.78	-25.16	-8.16
Commercial vehicles	+5.45	+ 5.45	+ 2.97	+ 5.22	+2.58

Source: Virginia Department of Highways and Transportation.

Table 13

Distribution of Travel by Vehicle Type, 1974

Vehicle Type	Projected (%)	Actual (%)	Significantly Different?
Virginia passenger cars	59.90	60.85	No
Out-of-state passenger cars	16.98	15.51	Yes
Single unit trucks	15.93	16.43	No
Tractor trailers and buses	7.19	7.2	No

Vehicle Mix

Vehicle mix refers to the distribution of different sizes and types of vehicles within the vehicle population. These sizes are generally measured by weight and market class of passenger car, while types refer to the distribution of trucks, motorcycles, bicycles, and passenger vehicles. Size is an influential component of the energy crisis due to the influx of small domestic and foreign cars. These small cars not only offered improved fuel economy, but were also initially somewhat less expensive than full- or mid-sized cars. The search for economic and inexpensive transportation affected vehicle mix in several ways. First, it affected buyer preferences in the size and weight of vehicles. In 1969, 20% of all new passenger cars were of the compact or subcompact classes. By 1973 this figure had risen to 40% and was accelerated during the early months of the energy shortage. Secondly, it affected the age of vehicles in the population, since rising prices made the purchase of a new car less practical than retaining an older model. Thirdly, it affected the driver's choice of type of vehicle, augmenting the existing trend of increased motorcycle and bicycle use. Each of these changes produced a subsequent change in the highway safety environment.

The relative sizes of vehicles within a driving population is related to accident involvement. Small cars tend to be more frequently involved in single vehicle crashes than are their larger counterparts.[29] Subcompacts also have a higher insurance claim frequency than do full-size cars (this may be an artifact of accident severity rather than accident involvement, due to the insurance practice of allowing claims only on accidents of particular severity). There is some speculation that the small sized engines with which compact cars are equipped are associated with crash involvement. Drivers of cars with low horsepower had higher accident involvement rates than drivers of vehicles equipped with higher horsepower enginers.[26]

The size of vehicles in a given population is also related to the severity of crash consequences. According to a study conducted in New York using a sample size of 400,000 crashes, the severity of a crash is strongly related to the weight of the involved vehicle.[30] "Results of this study showed a large exponential increase in the percent of serious and fatal inquiries with decreasing vehicle weight."[15] This relationship between size and severity is illustrated in Figure 13 and substantiated in other reports.[31,32,33]

The age of cars in the driving population is also an important factor in the distribution of vehicle types. Drivers of older cars have higher accident involvement rates than do drivers of newer cars.[21] This statement is intuitively correct for a number of reasons. In the past drivers of significantly older cars have tended to come from the lower socioeconomic classes; they form a group of drivers operating at greater risk than other drivers. Accidents involving these older cars may be caused more often by vehicle defects.[15] The increase of older cars into the population, due to the energy crisis and the economic situation, makes examination of this variable imperative.

Increases in the number of motorcycles and mopeds are also expected to have an effect upon accidents and injuries. Even before the onset of the energy shortage, motorcycle sales had accelerated. For instance, between 1969 and 1973, North Carolina's motorcycle registrations increased 104%, compared to an increase of 17% among passenger cars. During the same period, fatalities involving passenger cars increased 4%, while those involving motorcycles jumped 72.5%. The seriousness of motorcycle crashes is indicated by the fact that "once a motorcycle accident occurs, there is a high probability that a serious injury or fatality will result."[33] More than half of all single vehicle and about 80% of all multiple vehicle motorcycle crashes result in a serious injury or fatality.[34] Thus, motorcyclists have been shown to be operating under more risk than passenger car drivers. Even without the effects of the energy crisis, the safety problem which motorcycling now constitutes has been termed "epidemical."[34] In the quest for more economical forms of travel, the use of motorcycles is expected to increase at an expanded rate.

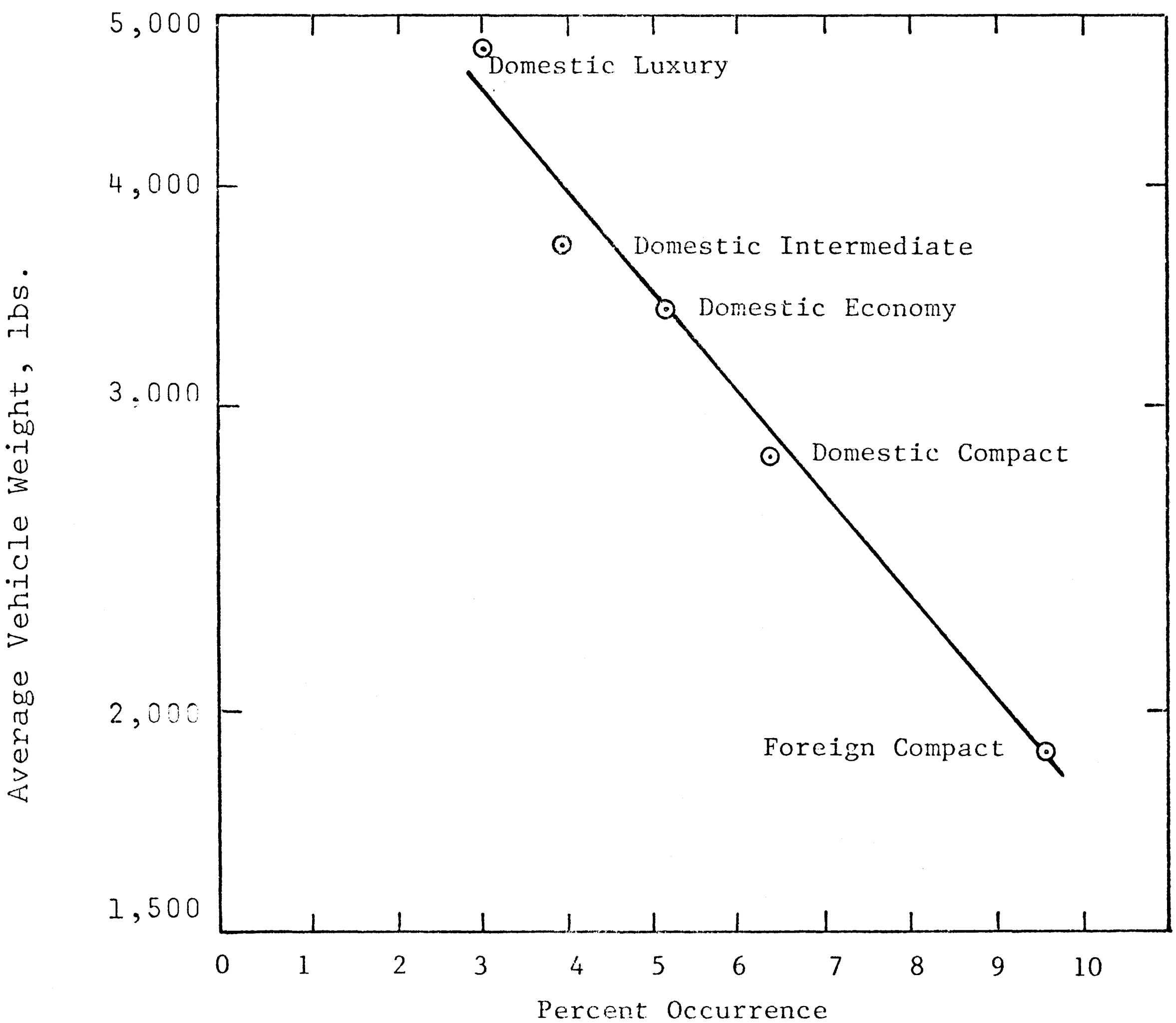

Figure 13. Percent of accident-involved vehicles in which the most serious injury was fatal or serious. (Adapted from New York State study conducted for DOT. Presented in "Key Issues in Highway Loss Reduction," Proceedings, IIHS 1970 Symposium,1970.

To determine if vehicle mix was a factor in the reduction in accidents in Virginia during the energy crisis, projections were made using linear regression in order to describe the "hypothetical" automobile population in the state based on pre-energy crisis trends. These estimates of what the population would have been like had there been no energy crisis were compared to actual figures to determine if real differences existed. While exact information on the sizes of vehicles in the population could not be solicited, information on new domestic and imported car registrations and on truck registrations were available from R. L. Polk and Company. These figures on the registration of new vehicles can provide an indication of trends within the vehicle population.

Since imported cars tend to be smaller in size and weight than domestic cars, an increase in imported car sales could affect the vehicle mix in Virginia. Table 14 compares the actual vs. the projected distribution of imported and domestic passenger cars. These distributions are virtually identical, which indicated that the proportion of small imported cars has not changed from what was expected during 1974. However, when the distribution of passenger cars and trucks was examined a significant difference was found (see Table 15). There were significantly more trucks registered during 1974 than would be expected based on previous trends, which would tend to change the vehicle mix and adversely affect the accident environment. In relation to truck size, Table 16 depicts truck registrations by weight of the vehicle. The actual and projected distributions were significantly different, with fewer light trucks and more heavy trucks being purchased. There are more trucks being sold into the vehicle population, which are by definition heavier than most passenger cars, and more of these are of the heavy truck category. This increase in truck weights could increase accident severity.

Thus, the size and weight of vehicles chosen by consumers did change during the energy crisis. Significant changes were also detected in the second type of vehicle mix variable, that of vehicle age (see Table 17). There appear to be more older cars in the population than would have been expected. If older cars in the population are more susceptible to vehicle defects which could result in accidents, then this change in vehicle mix could adversely affect accident experience.

In terms of the third possible change in vehicle mix, that of type of vehicle chosen, motorcycle registrations increased in 1974 (see Table 18). Due to a change in reporting time periods, projections based on previous trends could not be made. Using actual historical data rather than projections, distributions of motorcycles and passenger cars within the vehicle populations were still significantly different at the .001 level, indicating that the representation of motorcycles has increased significantly, not only across years but since 1973. From these findings, one would expect that these changes would result in more serious accident experiences.

In summary, there were significant changes in all three types of vehicle mix. In terms of size and weight, more and heavier trucks were introduced into the vehicle population compared to passenger cars. In terms of age, more older vehicles were being kept in the population rather than being discarded and replaced by newer models. Finally, more motorcycles were being registered in Virginia than ever before.

Table 14

Domestic vs. Imported New Car Registrations, 1974

Passenger Cars	Actual	Projected
Domestic	157,277 (82.2%)	205,162 (82.2%)
Imported	33,959 (17.8%)	44,391 (17.8%)
χ^2 = .06, Not Significant		

Table 15

Passenger Car vs. Truck Registrations, 1974

	Actual	Projected
Passenger Cars	191,236 (76.9%)	249,553 (80.2%)
Trucks	57,383 (23.1%)	61,703 (19.8%)
$\chi^2 = 875.47$, $p < .001$		

Table 16

Distribution of Truck Weights, 1974

Truck Weight	Actual	Projected
6,000 lb. or less	38,284 (66.7%)	41,612 (67.4%)
6,001 to 10,000	9,979 (17.4%)	10,510 (17.0%)
10,001 to 14,000	42 (0.1%)	102 (0.2%)
14,001 to 18,000	34 (0.1%)	90 (0.2%)
18,001 to 19,500	210 (0.4%)	58 (-)
19,501 to 26,000	4,888 (8.5%)	5,644 (9.2%)
26,001 to 33,000	505 (0.8%)	543 (0.8%)
33,001 and over	3,441 (6.0%)	3,143 (5.1%)
$\chi^2 = 201.64$, $p < .001$		

Table 17

Distribution of Vehicle Ages, 1974

Age	Actual	Projected
Current Year	131,884 (6.5%)	154,405 (7.8%)
1 Year old	266,161 (13.1%)	226,513 (11.5%)
2 Years old	237,557 (11.7%)	211,031 (10.7%)
3 Years old	199,360 (9.8%)	212,420 (10.8%)
4-5 Years old	378,985 (18.6%)	410,193 (20.8%)
6-7 Years old	305,283 (15.0%)	351,679 (17.8%)
8-9 Years old	263,296 (13.0%)	232,836 (11.8%)
10-12 Years old	187,797 (9.2%)	118,902 (6.0%)
13-15 Years old	37,450 (1.8%)	26,852 (1.4%)
> 15 Years old	25,320 (1.3%)	27,520 (1.4%)
$\chi^2 = 297.26$, $p < .001$		

Table 18

Distribution of Motorcycle and Passenger Car Registrations 1970-1975

	Motorcycles	Passenger Cars
January through June 1970	33,583 (1.7%)	1,898,163 (98.3%)
January through June 1971	41,396 (2.1%)	1,947,346 (97.9%)
January through June 1972	52,835 (2.3%)	2,280,053 (97.7%)
July 1973 through June 1974	93,992 (3.7%)	2,450,020 (96.3%)
χ^2 = 70-74 = 21256.9, $p < .001$		
χ^2 = 73-74 = 8520.44, $p < .001$		

Daylight Saving Time

On January 6, 1974, year-round daylight saving time was instituted on a national basis. Initially, it was anticipated that permanent daylight saving time would conserve energy and produce some safety benefits. Any detrimental effects of reduced visibility in morning hours were expected to be outweighed by the beneficial effects of increased visibility in the late afternoon and early evening hours.(7) However, there was considerable concern from several sources that energy savings attributed to daylight saving time were not worth the increased risk under which early morning travelers, especially school children, were operating. In response to this concern, and before concrete evidence of a safety hazard was presented, Congress exempted November through February from daylight saving time.

Evidence presented since the repeal of permanent daylight saving time indicates that the concern prompting its repeal was not well-founded:

1. The National Safety Council found no significant impact upon fatalities within the 4-18 year age bracket.(35)

2. Virginia had a slight increase in fatalities among the young, but was one of the few states with such an increase. This slight increase was so small as to possibly be caused by chance factors alone.

3. In neighboring North Carolina, daylight saving time produced no detrimental effects in terms of accidents and fatalities.

4. In California, the hypothesis that accident reductions during early evening hours would offset increases in accidents in the early morning was confirmed.[36] While fatalities in the 6-9 a.m. period increased 10.9%, fatalities in the 4-7 p.m. period decreased 14.9%, resulting in a net decrease of 4% (see Table 19).

Although this evidence is far from conclusive, and it must be remembered that other factors were at work affecting the accident environment, these findings indicate that concerns about permanent daylight saving time may be unwarranted.

To analyze the impact of daylight saving time in Virginia, projections for percentages of fatalities in morning and evening periods were compared with actual figures for 1974. It was found that actual fatalities in these figures were lower than projected levels. The decrease for the 6-9 a.m. period was statistically significant, indicating that there was no increase in risk during the morning hours (see Table 20). Thus, it was determined that winter daylight saving time imposed no detrimental effects in Virginia during the energy crisis.

Table 19

Percent of Total Fatalities by Time Period in California

Year	Percent of Accidents	
	6-9 a.m.	4-7 p.m.
1970	4.3	34.3
1971	6.2	23.7
1972	3.2	26.5
1973	5.9	30.6
70-73 Avg.	4.9	28.8
1974	15.8	13.9
Diff.	+10.9	-14.9

Table 20

Percent of Total Fatalities by Time Period in Virginia

Year	Percentage of Accidents	
	6-9 a.m.	4-7 p.m.
1969	6.0%	18.4%
1970	6.6%	17.9%
1971	7.2%	19.8%
1972	7.5%	20.5%
1973	7.6%	18.2%
1974 Projection	8.2%	19.6%
1974 Actual	7.1%	18.8%
	-1.1%	-0.8%

Occupancy Rates

While changes in occupancy should have little influence upon the number of accidents, they could have an impact upon the number of people injured in any given crash. Theoretically, if occupancy rates doubled, then the number of injuries and/or fatalities could double without a change in the total number of accidents. Of course, increases in occupancy rates may have beneficial effects by reducing the total number of miles traveled and auto density. Changes in occupancy rates may also have an impact upon injuries, since a number of injuries often result from body to body crashes within an accident vehicle. As cars become more crowded, there is a greater probability of a body to body collision.

During the energy crisis, car pooling became more popular than it previously had been and was strongly encouraged by the federal government. Accordingly, one would expect occupancy rates to rise. However, there is evidence from other sources that occupancy rates decreased during the first part of 1974 from a rate of 1.9 persons/car to 1.8 persons/car.[37] This decrease may be attributable to reduced high occupancy travel such as social or recreational outings. The fact that changes in occupancy rates are by-products of such things as reduced social travel indicates that their usefulness as an isolated factor to explain accident reduction is limited.

Safety Belt Usage

Although safety belt usage functions independently of the energy crisis, it must be considered since a large increase in safety belt usage could explain significant changes in accident patterns. The historical data available indicate that changes in rates of safety belt usage tend to be gradual, and that such gradual changes would have relatively little impact on accident experience over the short term. Studies of safety belt usage in Virginia indicate that there was very little change in safety belt usage between 1973 and 1974.(38) Therefore, a change in safety belt usage was not an important factor in the reduction in accidents.

SUMMARY OF FINDINGS

A number of energy crisis related factors were examined to determine if a change actually occurred in each during the energy crisis and if this change could be related to changes in the accident environment in Virginia during the same period.

In terms of speed, Virginia data supported the hypothesis that there were really two energy crisis effects relating to speed. Both mean speed and speed distribution changed during 1974. The data indicated that numbers of accidents decreased due to changes in speed distribution (reduced variability, especially) rather than due to changes in traveled speed. These differences in mean speed were more related to reduced accident severity than to accident occurrence.

While the literature supported the hypothesis that travel, or exposure, was related to accident occurrence, this notion was not supported by Virginia data. Both the amount of travel and numbers of accidents were highly correlated with year (both increased across time) and thus were highly correlated with each other. However, for any given year, the traffic volume of a given roadway system was not related to the number of accidents on that system (the only exception to this occurred for fatal accidents on arterial and primary roads where volume was negatively related to accidents).

In terms of vehicle mix, or the balance of sizes, weights and ages of vehicles on the road, the literature suggests that an influx of smaller, more economical passenger cars and motorcycles could lead to increases in the number and severity of accidents. Also, as it becomes more advantageous to repair an older car rather than purchase a new one, more accidents involving vehicle defects could result. In Virginia, while the distributions of imported vs. domestic cars did not change, more and heavier trucks were introduced into the vehicle population. Proportionally more older vehicles were also in use. These changes in the vehicle population would have offset some of the beneficial aspects of the energy crisis.

In relation to the temporary change to "permanent" daylight saving time, expected detrimental effects of reduced visibility in the morning were not realized. Fatal accidents were reduced in both time periods affected by the change, dusk and dawn; although most of the reduction occurred during the morning hours.

Finally, the small nationwide reduction in occupancy rates may have decreased the fatality or injury potential of any given crash; however, this reduction in occupancy rates and small changes in seat belt usage are so gradual that they would not be expected to have influenced the traffic safety environment during the energy crisis.

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