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Economic Cost of Traffic Accidents

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Contents

Economic Cost of Traffic Accidents in Relation to the Highway

BERNARD B. TWOMBLY, Traffic Engineer, Department of Public Works, Boston, Mass.

The traffic accident toll in number of persons killed and injured has been publicized so frequently that many people are quite familiar with the figures and can even relate the details of the latest fatal accident. Few persons, however, have an intimate knowledge of where, on a statewide basis, most of the collisions are occurring, what types are most frequent and what would be the odds, as measured in number of accidents per 100 million vehicle-miles, of having an accident on the Massachusetts streets and highways. Prior to the 1954-55 Accident Cost Study in Massachusetts which was conducted by the Massachusetts Department of Public Works and the Registry of Motor Vehicles in cooperation with the U. S. Bureau of Public Roads, the monetary cost of traffic accidents was purely conjectural.

This paper shows what this Accident Cost Study has revealed in terms of accident rates and direct costs of accidents on the six highway systems in Massachusetts and to point out where special attention should be directed in order to stem the tide of rising accident toll at its highest points.

It is reasonable to expect that the conditions which prevail in Massachusetts are typical of those in most other states.

● **THE HIGHWAY NETWORK** in Massachusetts can be divided into six systems whose total mileage in 1953 was 24,506 mi. This mileage had increased to 26,310 by 1958. The breakdown in mileage and in traffic volumes on each system during 1953—the year on which the Accident Cost Study was based—is as follows:

Highway Systems	Miles (A)	Average Traffic Volumes (B) (Vehicles)	Million Vehicle-Miles (AxB)
Federal-aid primary			
State highways	1,516	2,657,000	4,028
Local systems	452	3,170,000	1,433
Federal-aid secondary			
State highways	438	991,000	434
Local systems	1,748	894,000	1,563
Non-Federal aid			
State highways	155	1,381,000	214
Local systems	20,197	196,000	3,956
Grand Total	24,506	474,000	11,628

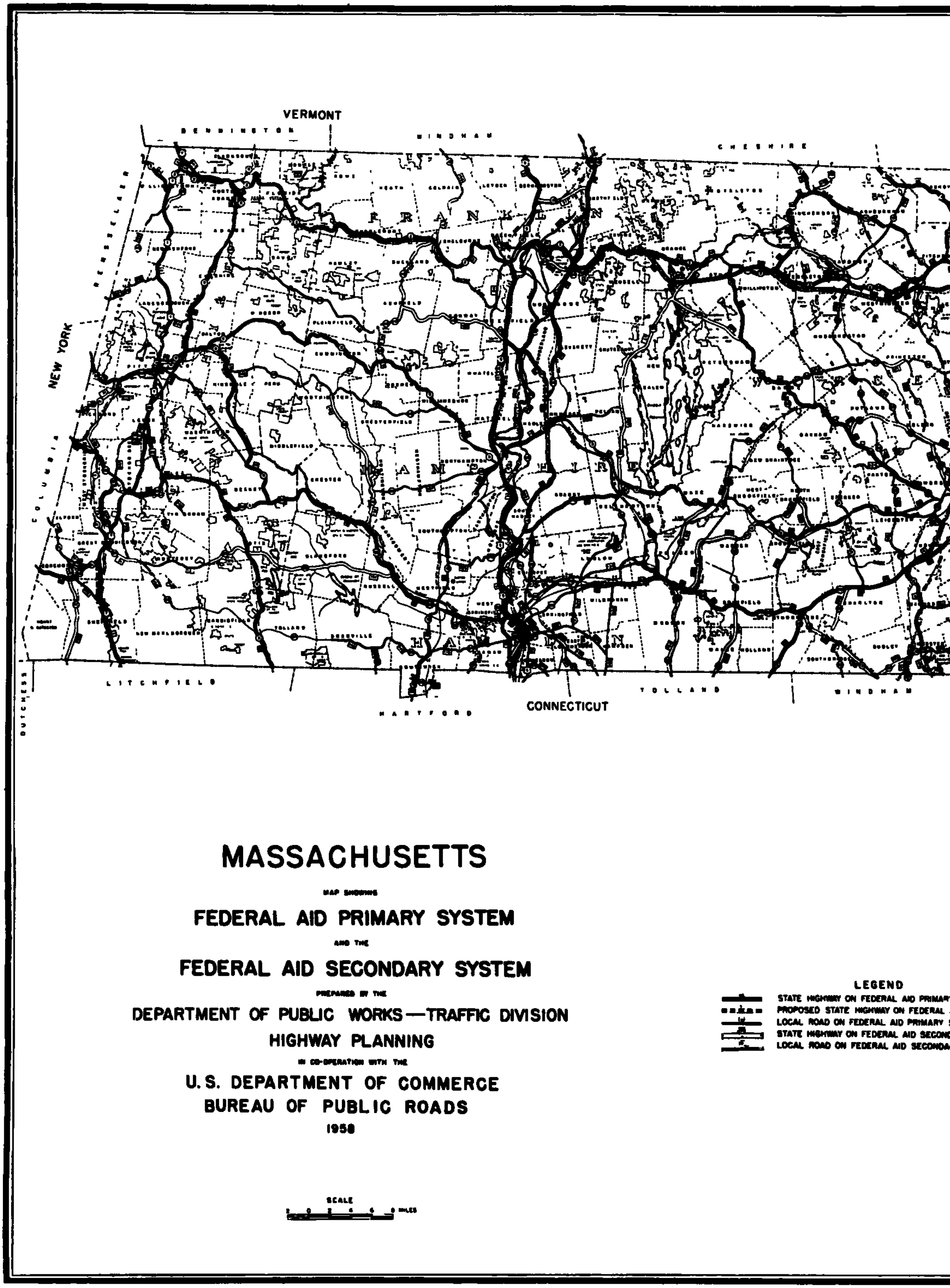
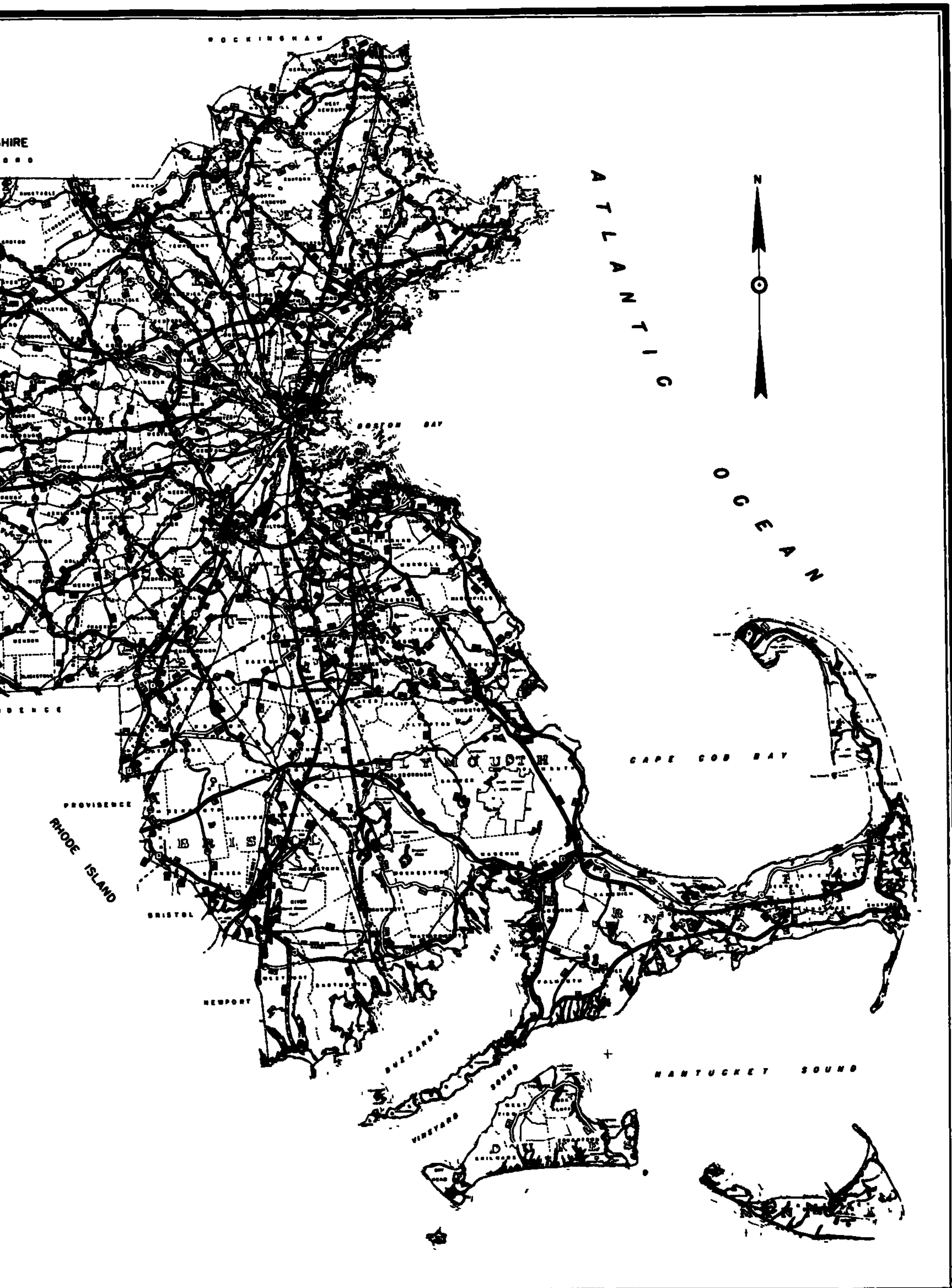

VERMONT
NEW YORK
CONNECTICUT
MASSACHUSETTS
FEDERAL AID PRIMARY SYSTEM
FEDERAL AID SECONDARY SYSTEM
DEPARTMENT OF PUBLIC WORKS—TRAFFIC DIVISION
HIGHWAY PLANNING
U. S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
1958
LEGEND

Figure 1



Massachusetts.

It may be of interest to know what the networks of highways in Massachusetts look like and although map space does not permit the inclusion of all roads, Figure 1 does show the extent and alignment of the Federal-aid highways. Massachusetts is probably not unique among the states in having a high percentage of curves in its roads. As shown on the map the number of long straight highways is still low. This is due to the ground contour, the large number of cities and towns, and to connecting roadways which follow alignment established many years ago. The rapidly expanding expressway system in this state will, in the next few years, certainly be effective in increasing the mileage of highways with better alignment.

GENERAL ACCIDENT EXPERIENCE

As brought out in Dunman's paper (HRB Bull. 208), there were, in 1953, 1,239,000 registered passenger cars and 1,858,000 licensed operators in Massachusetts.

The vehicle-miles driven in passenger cars during 1953 on the Commonwealth's 24,500 mi of highways totaled 11,628,000,000.

In this same year, Accident Cost Study figures show that 131,500 passenger car accidents occurred which resulted in a direct cost of $50,224,000.

Under the Massachusetts law until June 30, 1953, compulsory reporting to the Registrar of Motor Vehicles included only those cases involving personal injury. On June 30, 1953 the law was revised to include the compulsory reporting of accidents in which any person was killed or injured or in which there was damage in excess of $100 to any one vehicle or other property. The $100 limit was raised to $200 by another revision in the law on June 25, 1956. Registry figures in 1953 show 36,113 personal-injury accidents reported, while in 1954 a total of 67,626 personal-injury and property-damage accidents were reported. The difference between the figures used in this paper and the Registry figures of reported accidents is due to the large number of non-reportable property damage collisions.

ACCIDENT EXPERIENCE BY HIGHWAY SYSTEMS

Massachusetts, though densely populated in many sections, still has a low proportion of urban areas when compared with rural areas. Approximately 15 percent of the 8,093 sq mi in Massachusetts are classed as urban and 85 percent as rural.

Table 1, the basic accident table, shows that 88 percent of all accidents in the state occur in the urban areas, whose road mileage is 6,480 of the state's 24,506 mi. This point is a most enlightening one when considering density of accidents on the various highway systems. Moreover, in the urban areas, the major trouble occurs in the 39 cities of the Commonwealth where, according to Registry of Motor Vehicle figures in 1953, 67 percent of the total collisions in the state occurred.

Table 1 also furnishes a comparison of the accident experience on the state highway and local road systems. Without, for the moment, considering road mileage and traffic volumes, the 24,562 accidents on the state highways in comparison with the 106,974 accidents on the local road system clearly show where the chief problem in accident reduction lies. The figures in Table 1 substantiate the conclusion that special attention should be focused on the urban areas in the state and on the local road systems, if appreciable reductions in accidents are to be effected.

The Federal-aid systems, both primary and secondary, accounted for 47,681, or 36 percent of the 131,536 accidents. Of the 47,681 accidents, 24,080 occurred on state highways and 23,601 on local roads.

In terms of "severity" of accident the property-damage class far outweighs the other two classes of accidents. Without the facts it is difficult to realize that 97,951 "property damage only" collisions occur in one year and that these comprise 75 percent of all accidents. Local systems account for 80 percent of the property-damage accidents.

TABLE 1

MOTOR-VEHICLE TRAFFIC ACCIDENTS BY HIGHWAY SYSTEM AND SEVERITY FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953

	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
Highway System	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Federal-aid Primary system												
State highways	40	33	73	1,903	2,249	4,152	4,481	8,703	13,184	6,424	10,985	17,409
Local systems	-	49	49	15	5,216	5,231	-	12,081	12,081	15	17,346	17,361
Total	40	82	122	1,918	7,465	9,383	4,481	20,784	25,265	6,439	28,331	34,770
Federal-aid secondary system												
State highways	24	5	29	576	410	986	3,257	2,399	5,656	3,857	2,814	6,671
Local systems	-	20	20	30	1,514	1,544	-	4,676	4,676	30	6,210	6,240
Total	24	25	49	606	1,924	2,530	3,257	7,075	10,332	3,887	9,024	12,911
Non-Federal-aid system												
State highways	-	-	-	120	-	120	90	272	362	210	272	482
Local systems	26	118	144	1,304	19,933	21,237	4,676	57,316	61,992	6,006	77,367	83,373
Total	26	118	144	1,424	19,933	21,357	4,766	57,588	62,354	6,216	77,639	83,855
Total Federal-aid state highways	64	38	102	2,479	2,659	5,138	7,738	11,102	18,840	10,281	13,799	24,080
Total Federal-aid local systems	-	69	69	45	6,730	6,775	-	16,757	16,757	45	23,556	23,601
Total Federal-aid systems	64	107	171	2,524	9,389	11,913	7,738	27,859	35,597	10,326	37,355	47,681
Total state highways	64	38	102	2,599	2,659	5,258	7,828	11,374	19,202	10,491	14,071	24,562
Total local systems	26	187	213	1,349	26,663	28,012	4,676	74,073	78,749	6,051	100,923	106,974
Total all systems	90	225	315	3,948	29,322	33,270	12,504	85,447	97,951	16,542	114,994	131,536

ACCIDENT EXPERIENCE BY HIGHWAY SYSTEMS
(In Relation to Highway Mileage and Traffic Volumes)

In the rate comparisons given, the efficiencies of the various systems in accident prevention are made evident. Tables 2 and 3 both give accident rates, Table 2 in accidents per mile and Table 3 in accidents per 100 million vehicle-miles. Table 3 is perhaps of more value because it employs the widely accepted method of comparison of accident experience on highways.

TABLE 2

MOTOR-VEHICLE TRAFFIC ACCIDENTS PER MILE OF HIGHWAY BY HIGHWAY SYSTEM AND SEVERITY FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953[1]

	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
Highway System	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Federal-aid primary system												
State highways	0.03	0.08	0.04	1.70	5.66	2.73	4.00	21.92	8.69	5.73	27.67	11.48
Local systems	-	0.14	0.10	0.12	15.66	11.57	-	36.27	26.72	0.12	52.09	38.40
Total	0.03	0.11	0.06	1.54	10.22	4.76	3.61	28.47	12.83	5.20	38.80	17.66
Federal-aid secondary system												
State highways	0.06	0.06	0.06	1.60	5.18	2.25	9.07	30.36	12.91	10.74	35.62	15.23
Local systems	-	0.04	0.01	0.02	3.38	0.88	-	10.46	2.67	0.02	13.89	3.56
Total	0.01	0.04	0.02	0.36	3.65	1.15	1.96	13.45	4.72	2.34	17.15	5.90
Non-Federal-aid system												
State highways	-	-	-	0.85	-	0.77	0.63	19.42	2.33	1.48	19.42	3.10
Local systems	0.00	0.02	0.00	0.08	3.82	1.05	0.31	11.00	3.06	0.40	14.84	4.12
Total	0.00	0.02	0.00	0.09	3.81	1.04	0.31	11.02	3.06	0.41	14.86	4.12
Total Federal-aid state highways	0.04	0.07	0.05	1.67	5.58	2.62	5.23	23.32	9.64	6.95	28.98	12.32
Total Federal-aid local systems	-	0.08	0.03	0.03	8.62	3.07	-	21.48	7.61	0.03	30.20	10.72
Total Federal-aid systems	0.02	0.08	0.04	0.87	7.47	2.86	2.67	22.18	8.56	3.56	29.74	11.47
Total state highway	0.03	0.07	0.04	1.60	5.42	2.49	4.83	23.21	9.10	6.47	28.71	11.64
Total local systems	0.00	0.03	0.00	0.08	4.45	1.25	0.28	12.36	3.51	0.36	16.84	4.77
Total all systems	0.005	0.03	0.01	0.21	4.52	1.35	0.69	13.18	3.99	0.91	17.74	5.36

[1] Derived from Tables 1 and 4.

TABLE 3

MOTOR-VEHICLE TRAFFIC ACCIDENTS PER 100 MILLION VEHICLE-MILES BY HIGHWAY SYSTEM AND SEVERITY FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953[1]

	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
Highway System	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Federal-aid primary system												
State highways	1.88	1.73	1.81	89.59	118.11	103.07	210.96	457.09	327.30	302.40	576.94	432.17
Local systems	-	3.91	3.41	8.33	416.28	365.03	-	964.16	843.05	8.33	1,384.35	1,211.51
Total	1.73	2.59	2.23	83.24	236.45	171.81	194.48	658.34	462.64	279.42	897.40	636.67
Federal-aid secondard system												
State highways	7.92	3.81	6.68	190.09	312.97	227.18	1,074.91	1,831.29	1,303.22	1,273.26	2,148.09	1,537.32
Local systems	-	2.49	1.27	3.93	189.01	98.78	-	583.77	299.16	3.93	775.28	399.23
Total	2.25	2.68	2.45	56.90	206.43	126.69	305.82	759.12	517.37	365.07	968.24	646.56
Non-Federal-aid system												
State highways	-	-	-	72.28	-	56.07	54.21	566.66	169.15	126.50	566.66	225.23
Local systems	1.10	7.34	3.64	55.48	1,241.15	536.83	198.97	3,568.86	1,567.03	255.57	4,817.37	2,107.50
Total	1.03	7.13	3.45	56.59	1,205.13	512.15	189.42	3,481.74	1,495.29	247.05	4,694.01	2,010.91
Total Federal-aid state highways	2.63	1.86	2.28	102.14	130.66	115.15	318.82	545.55	422.23	423.60	678.08	539.66
Total Federal-aid local systems	-	3.35	2.30	4.77	327.65	226.13	-	815.82	559.31	4.77	1,146.83	787.75
Total Federal-aid systems	1.89	2.61	2.29	74.91	229.61	159.73	229.68	681.31	477.29	306.50	913.54	639.32
Total state highways	2.46	1.82	2.18	100.23	127.65	112.44	301.88	546.03	410.65	404.58	675.51	525.27
Total local systems	0.78	5.10	3.06	40.97	728.49	402.93	142.04	2,023.85	1,132.75	183.80	2,757.45	1,538.75
Total all systems	1.52	3.91	2.70	67.08	510.56	286.11	212.47	1,487.84	842.37	281.08	2,002.33	1,131.20

[1] Derived from Tables 1 and 5.

Table 2 does indicate frequency of accidents. It shows that the average number of accidents per mile per year on the state highways is 11.6 as compared with 4.7 on local roads. On these two systems their respective mileages were 2,109 and 22,397. Thus the frequency of accidents on the state highways is more than double that on the local roads, but the state highways constitute only 9 percent of the road mileage in the state.

TABLE 4

MILEAGE BY HIGHWAY SYSTEM IN MASSACHUSETTS: 1953

Highway System	Rural	Urban	Total
Federal-aid primary system			
State highways	1,119	397	1,516
Local systems	119	333	452
Total	1,238	730	1,968
Federal-aid secondary system			
State highways	359	79	438
Local systems	1,301	447	1,748
Total	1,660	526	2,186
Non-Federal-aid system			
State highways	141	14	155
Local systems	14,987	5,210	20,197
Total	15,128	5,224	20,352
Total Federal-aid state highways	1,478	476	1,954
Total Federal-aid local systems	1,420	780	2,200
Total Federal-aid systems	2,898	1,256	4,154
Total state highways	1,619	490	2,109
Total local systems	16,407	5,990	22,397
Total all systems	18,026	6,480	24,506

Table 4 gives the total mileages and Table 5 the total vehicle-miles on each highway system.

It might be noted here that 4,676 million vehicle-miles of travel were recorded on the state highways and 6,952 million vehicle-miles on the local road systems.

TABLE 5

VEHICLE-MILES OF TRAVEL BY PASSENGER CARS ON LOCAL ROADS AND HIGHWAYS BY HIGHWAY SYSTEM IN MASSACHUSETTS: 1953

	Rural	Urban	Total
Highway System	Vehicle-Miles	Vehicle-Miles	Vehicle-Miles
Federal-aid primary system			
State highways	2,124	1,904	4,028
Local systems	180	1,253	1,433
Total	2,304	3,157	5,461
Federal-aid secondary system			
State highways	303	131	434
Local systems	762	801	1,563
Total	1,065	932	1,997
Non-Federal-aid system			
State highways	166	48	214
Local systems	2,350	1,606	3,956
Total	2,516	1,654	4,170
Total Federal-aid state highways	2,427	2,035	4,462
Total Federal-aid local systems	942	2,054	2,996
Total Federal-aid system	3,369	4,089	7,458
Total state highways	2,593	2,083	4,676
Total local systems	3,292	3,660	6,952
Total all systems	5,885	5,743	11,628

The accident rates in Table 3 are most revealing. The figures show the following comparisons in accident rates on each system:

1. In the Federal-aid primary system the accident rate (accidents per 100 million vehicle-miles) on the state highways is 432, and 1,211 on local roads.
2. In the Federal-aid secondary system the ratios are reversed with 1,537 accidents per 100 million vehicle-miles on the state highways and 399 on local roads.
3. In the non-Federal-aid system there is a preponderance of mileage on the local roads. There are 225 accidents per 100 million vehicle-miles on the state highways and 2,107 on local roads.

A consideration of the exposure data may be helpful on analyzing the reversal of ratios in the two Federal-aid groups. The average volumes carried on each subdivision in the Federal-aid primary (FAP) system are not too different. This is also true of the total number of accidents in each subdivision of this system. Therefore, accident rates expressed in accidents per 100 M. V. M. vary inversely with respect to mileage. The same is approximately true of state highway and local road subdivisions in the Federal-aid secondary (FAS) system. Thus, in the primary system, the state highway road mileage is three times that on the local roads whereas its accident rate is only one-third that of the local roads.

In the secondary system, the state highway mileage is one-fourth that on the local roads and the state highway accident rate is four times that of the local roads.

The reversal of accident ratios in the various systems became the cause of special study in an attempt to determine the reason therefor. Comparisons of the number of accidents per mile of highway and the number of accidents per million vehicle-miles were both studied in relation to their respective system mileages.

In neither of these possibilities could a definite indication or trend be detected.

There did appear to be a relationship between the number of accidents in terms of vehicle-miles as related to their average traffic volumes. However, this was not sufficiently pronounced to substantiate any definite conclusions as to the reasons for the variation of accident rates in the various systems.

A possible interim conclusion might be that the priority given to the construction of limited-access highways on the FAP system, and financial assistance to the municipalities for local roads in the FAS system since World War II have reduced the accident rates on those systems.

These results do lead to the conclusion that on an accident rate basis, the state highways in the FAP system and the local roads in the FAS system are doing a good job. On the contrary, the results in terms of accident rates on the local roads in the FAP system and the state highways in the FAS system indicate a definite need for improvement on these systems.

This need for improvement most certainly obtains in the case of the non-Federal-aid local roads with their high accident totals, extensive mileage and high rate of accidents per 100 million vehicle-miles.

ECONOMIC COSTS—TOTAL

The foregoing has been purposely confined to an explanation of accident experience and accident rates on the roadway systems. This was done in order to promote a clearer understanding of the accident picture in Massachusetts. It is a fact, however, that an important and integral part of any motor-vehicle accident—and aside from the aspect of personal injury, suffering and inconvenience involved—is the monetary cost incurred.

In this paper monetary costs are confined to "direct" costs only. "Direct" costs are defined as the money value of damages and losses to persons and property that were the direct result of these accidents and which might have been saved for the car owner had these accidents not occurred. "Direct" costs are composed of the money value of damage to property, hospitalization, doctors, dentists, and nursing service, ambulance use, medicine, work time lost, damages awarded in excess of other direct costs, attorney's services, court fees, and other miscellaneous but small items.

The Economic Cost of Accidents in Relation to the Highway Systems is given in Tables 6 and 7.

Table 6 covers the over-all costs and Table 7 gives a breakdown showing average cost per accident on each highway system. The value of Table 7 is that it brings into sharp focus the cost to an individual of having an accident and that the cost may vary from $203, the figure for an average property-damage accident, up to $5,499 for an average fatal accident in urban areas.

For those who include among their responsibilities the improvement of accident-prone highways the over-all costs of accidents on the highway systems in Table 6 are of special significance.

In 1953 there occurred a total of 131,536 accidents which involved $50,223,500 in direct costs. Fatal accidents made up 3 percent, non-fatal injury accidents 57 percent and property-damage accidents 40 percent of this cost.

Earlier it was stated that an attempt would be made to point out where special attention is needed in order to reduce accidents and economic costs. The cost breakdown by highway systems provides a means for highlighting the enormous cost of accident-prone highways.

In this cost breakdown it is interesting to examine the cost comparisons in the light of what was previously found through accident rate comparisons. This may be done in three sections as before.

1. Federal-aid primary system. — State highways have a better accident rate than local roads in the ratio of 1 to 3 (Table 3). However, the state highway accident costs (Table 6) exceed those on the local roads, being $9,909,530 and $7,282,410 respectively.

The highest costs in each subdivision of the FAP system are those incurred in urban non-fatal accidents; that is, in accidents where non-fatal injuries are involved and they amounted to $8,863,230. State and local roads each show a total cost of approximately $4,400,000. Thus, in the non-fatal injury accident category, urban areas accounted for 52 percent of the total cost in the FAP system while the state highways make up almost all of the cost in the rural areas.

Property-damage accidents were especially costly in both rural and urban subdivisions but these costs were only 52 percent of the non-fatal figures.

2. Federal-aid secondary system. — On these roads the total accident cost is only 29 percent of that on the FAP roads or $5,036,540 to $17,191,940.

Here again the dissimilarity between accident rate comparisons and cost comparisons is worthy of note. On the FAS system local roads have a comparatively low accident rate and state highways a much greater one in the ratio of 4 to 15. Nevertheless, the accident costs are in the ratio of only 4 to 6 on local roads vs state highways.

Another noteworthy fact is that property damage costs are greater on the FAS system than are those of non-fatal injury accidents. This is due to a preponderance of minor, less-costly accidents on the FAS system.

3. Non-Federal-aid system. — These roads form the large network of local streets and connecting highways. Compared with the roads in the other systems they carry less average traffic, their accident rate expressed in number of accidents per mile is less and yet because they compose 20,352 of the state's 24,506 mi they account for 83,855 accidents which cost $27,995,020 out of the total $50,223,500.

Non-fatal injury accidents account for $15,974,500, property-damage accidents for $11,269,060, and fatal accidents for $751,460 of the $27,995,020.

TABLE 6

DIRECT COSTS OF MOTOR-VEHICLE TRAFFIC ACCIDENTS BY HIGHWAY SYSTEM AND SEVERITY FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953

	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
Highway System	Rural ($)	Urban ($)	Total ($)	Rural ($)	Urban ($)	Total ($)	Rural ($)	Urban ($)	Total ($)	Rural ($)	Urban ($)	Total ($)
Federal-aid primary system												
State highways	214,420	179,750	394,170	1,920,530	4,428,550	6,349,080	1,189,760	1,976,520	3,166,280	3,324,710	6,584,820	9,909,530
Local systems	-	268,640	268,640	28,800	4,434,680	4,463,480	-	2,550,290	2,550,290	28,800	7,253,610	7,282,410
Total	214,420	448,390	662,810	1,949,330	8,863,230	10,812,560	1,189,760	4,526,810	5,716,570	3,353,510	13,838,430	17,191,940
Federal-aid secondary system												
State highways	83,700	28,820	111,920	528,500	416,980	945,480	655,220	1,290,530	1,945,750	1,267,420	1,735,730	3,003,150
Local systems	-	115,560	115,560	4,500	950,410	954,910	-	962,920	962,920	4,500	2,028,890	2,033,390
Total	83,700	143,780	227,480	533,000	1,367,390	1,900,390	655,220	2,253,450	2,908,670	1,271,920	3,764,620	5,036,540
Non-Federal-aid system												
State highways	-	-	-	134,400	-	134,400	5,430	19,910	25,340	139,830	19,910	159,740
Local systems	106,390	645,070	751,460	859,200	14,980,900	15,840,100	695,040	10,548,680	11,243,720	1,660,630	26,174,650	27,835,280
Total	106,390	645,070	751,460	993,600	14,980,900	15,974,500	700,470	10,568,590	11,269,060	1,800,460	26,194,560	27,995,020
Total Federal-aid state highways	298,120	207,970	506,090	2,449,030	4,845,530	7,294,560	1,844,980	3,267,050	5,112,030	4,592,130	8,320,550	12,912,680
Total Federal-aid local systems	-	384,200	384,200	33,300	5,385,090	5,418,390	-	3,513,210	3,513,210	33,300	9,282,500	9,315,800
Total Federal-aid systems	298,120	592,170	890,290	2,482,330	10,230,620	12,712,950	1,844,980	6,780,260	8,625,240	4,625,430	17,603,050	22,228,480
Total state highways	298,120	207,970	506,090	2,583,430	4,845,530	7,428,960	1,850,410	3,286,960	5,137,370	4,731,960	8,340,460	13,072,420
Total local systems	106,390	1,029,270	1,135,660	892,500	20,365,990	21,258,490	695,040	14,061,890	14,756,930	1,693,930	35,457,150	37,151,080
Total all systems	404,510	1,237,240	1,641,750	3,475,930	25,211,520	28,687,450	2,545,450	17,348,850	19,894,300	6,425,890	43,797,610	50,223,500

TABLE 7

DIRECT COSTS PER MOTOR-VEHICLE TRAFFIC ACCIDENTS BY HIGHWAY SYSTEM AND SEVERITY FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953[1]

	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
Highway System	Rural ($)	Urban ($)	Total ($)	Rural ($)	Urban ($)	Total ($)	Rural ($)	Urban ($)	Total ($)	Rural ($)	Urban ($)	Total ($)
Federal-aid primary system												
State highways	5,361	5,447	5,400	1,009	1,969	1,529	266	227	240	518	599	569
Local systems	-	5,482	5,482	1,920	850	853	-	211	211	1,920	418	419
Total	5,361	5,468	5,433	1,016	1,187	1,152	266	218	226	521	488	494
Federal-aid secondary system												
State highways	3,488	5,644	3,859	918	1,017	959	201	538	344	329	617	450
Local systems	-	5,778	5,778	150	628	618	-	206	206	150	327	326
Total	3,488	5,751	4,642	880	711	751	201	319	282	327	417	390
Non-Federal-aid system												
State highways	-	-	-	1,120	-	1,120	60	73	70	666	73	331
Local systems	4,092	5,467	5,218	659	752	746	149	184	181	276	338	334
Total	4,092	5,467	5,218	698	752	748	147	184	181	290	337	334
Total Federal-aid state highways	4,658	5,473	4,962	988	1,822	1,420	238	294	271	447	603	536
Total Federal-aid local systems	-	5,568	5,568	740	800	800	-	210	210	740	394	395
Total Federal-aid systems	4,658	5,534	5,206	783	1,090	1,067	238	243	242	448	471	466
Total state highways	4,658	5,473	4,962	994	1,822	1,413	236	289	268	451	593	532
Total local systems	4,092	5,504	5,332	662	7,639	759	149	190	187	280	351	347
Total all systems	4,495	5,499	5,212	880	860	862	204	203	203	388	381	382

[1] Derived from Tables 1 and 6.

Of this amount $26,194,560 was incurred in urban areas. Thus besides having a high accident rate in terms of accidents per 100 million vehicle-miles on its local road subdivision, the non-Federal-aid (NFA) system is responsible for 56 percent of the monetary cost of accidents in the state.

ECONOMIC COSTS—RATES

The total costs of accidents on each highway system (Table 6) permits a comparison of total monetary costs.

As previously noted the efficiency of a highway in terms of accidents may be obtained by comparing accident rates. This is also true when comparing economic loss expressed in accident cost rates.

Cost rates are given in Tables 8 and 9 and shown in Figures 2 and 3.

Figure 2 shows costs per mile of highway on each highway system and Figure 3 shows costs per 100 million vehicle-miles.

An analysis of Figure 2 indicates that the highest accident cost per mile of highway, $16,112, is on the FAP local roads. Second highest is $6,857 on FAS state highways and third $6,537 on FAP state highways. Costs per mile on the remaining systems are minor in comparison. It should be stressed here that these costs are average costs only and that costs fluctuate greatly on the many types of roadways in each system. Costs per mile, of course, present only one side of the picture and do not reflect the volumes of traffic carried.

Figure 3 shows cost on a vehicle-mile basis.

The comparison obtainable in Figure 3 may be further simplified by reducing the cost per 100 million vehicle-miles, in dollars, to the cost per car-mile expressed in cents.

The state highways as a whole are costing the motorist an average of 0.28 cents per car-mile while the local roads are costing the motorist 0.53 cents per car-mile as shown in the following comparative summary of the total costs per passenger car-mile on each system:

System	Costs in Cents	
	S. H.	Local Roads
FAP	0.24	0.50
FAS	0.69	0.13
NFA	0.07	0.70

ECONOMIC COST BY TYPES OF COLLISIONS

The two main sections into which types of accidents may be grouped are (1) collisions between two or more vehicles and (2) accidents involving only one vehicle (Table 10). Subdivisions of the first group include head-on, read-end, angle, sideswipe (same direction) sideswipe (opposite direction), and other collisions. The last group

TABLE 8

DIRECT COSTS OF MOTOR-VEHICLE TRAFFIC ACCIDENTS PER MILE OF HIGHWAY BY HIGHWAY SYSTEM AND SEVERITY FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953[1]

	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
Highway System	Rural ($)	Urban ($)	Total ($)	Rural ($)	Urban ($)	Total ($)	Rural ($)	Urban ($)	Total ($)	Rural ($)	Urban ($)	Total ($)
Federal-aid primary system												
State highways	192	453	260	1,716	11,155	4,188	1,063	4,979	2,089	2,971	16,586	6,537
Local systems	-	807	594	242	13,317	9,875	-	7,659	5,642	242	21,783	16,112
Total	173	614	337	1,575	12,141	5,494	961	6,201	2,905	2,709	18,957	8,736
Federal-aid secondary system												
State highways	233	357	256	1,472	5,278	2,159	1,825	16,336	4,442	3,530	21,971	6,857
Local systems	-	259	66	3	2,126	546	-	2,154	551	3	4,539	1,163
Total	50	273	104	321	2,600	869	395	4,284	1,331	766	7,157	2,304
Non-Federal-aid system												
State highways	-	-	-	953	-	867	39	1,422	163	992	1,422	1,031
Local systems	7	124	37	57	2,875	784	46	2,025	557	111	5,024	1,378
Total	7	123	37	66	2,868	785	46	2,023	554	119	5,014	1,376
Total Federal-aid state highways	202	437	259	1,657	10,180	3,733	1,248	6,864	2,616	3,107	17,480	6,608
Total Federal-aid local systems	-	493	175	23	6,904	2,463	-	4,504	1,597	23	11,901	4,234
Total Federal-aid systems	103	471	214	857	8,145	3,060	637	5,398	2,076	1,596	14,015	5,351
Total state highways	184	424	240	1,596	9,889	3,523	1,143	6,708	2,436	2,923	17,021	6,198
Total local systems	6	172	51	54	3,400	949	42	2,348	659	103	5,919	1,659
Total all systems	22	191	67	19	3,891	1,171	141	2,677	812	356	6,759	2,049

[1] Derived from Tables 4 and 6.

TABLE 9

DIRECT COSTS OF MOTOR-VEHICLE TRAFFIC ACCIDENTS PER 100 MILLION VEHICLE-MILES BY HIGHWAY SYSTEM AND SEVERITY FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953[1]

	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
Highway System	Rural ($)	Urban ($)	Total ($)	Rural ($)	Urban ($)	Total ($)	Rural ($)	Urban ($)	Total ($)	Rural ($)	Urban ($)	Total ($)
Federal-aid primary system												
State highways	10,095	9,441	9,786	90,420	232,592	157,624	56,015	103,809	78,607	156,531	345,841	246,016
Local systems	-	21,440	25,725	16,000	253,925	311,478	-	203,535	177,969	16,000	578,899	508,193
Total	9,306	14,203	12,137	84,606	280,748	197,996	51,639	143,390	104,680	145,552	438,341	314,813
Federal-aid secondary system												
State highways	27,624	21,542	25,788	174,422	318,305	217,853	216,244	985,137	448,329	418,290	1,324,985	691,970
Local systems	-	14,427	7,393	591	118,653	61,095	-	120,215	61,607	591	253,295	130,095
Total	7,859	15,427	11,391	50,047	146,716	95,162	61,523	241,786	145,652	119,429	403,929	252,205
Non-Federal-aid system												
State highways	-	-	-	80,964	-	62,804	3,271	41,479	11,841	84,235	41,479	74,645
Local systems	4,527	40,166	18,995	36,562	932,808	400,407	29,576	656,829	284,219	70,665	1,629,804	703,622
Total	4,229	39,001	18,021	39,491	905,738	383,082	27,841	538,972	270,241	71,560	1,583,710	671,343
Total Federal-aid state highways	12,283	10,220	11,342	100,908	238,110	163,482	76,019	160,543	114,568	189,210	406,872	289,392
Total Federal-aid local systems	-	18,705	12,824	3,535	262,176	180,854	-	171,042	117,263	3,535	451,923	310,941
Total Federal-aid systems	8,849	14,462	11,937	73,682	250,199	170,461	54,763	165,817	115,651	137,294	430,498	298,049
Total state highways	11,497	9,984	10,823	99,631	232,623	158,874	71,362	157,799	109,867	182,490	400,406	279,564
Total local systems	3,232	28,122	16,336	27,111	556,448	305,790	21,113	384,205	212,269	51,456	968,775	534,394
Total all systems	6,874	21,543	14,119	59,064	438,996	246,710	43,253	302,087	171,090	109,191	762,626	431,919

[1] Derived from Tables 5 and 6.

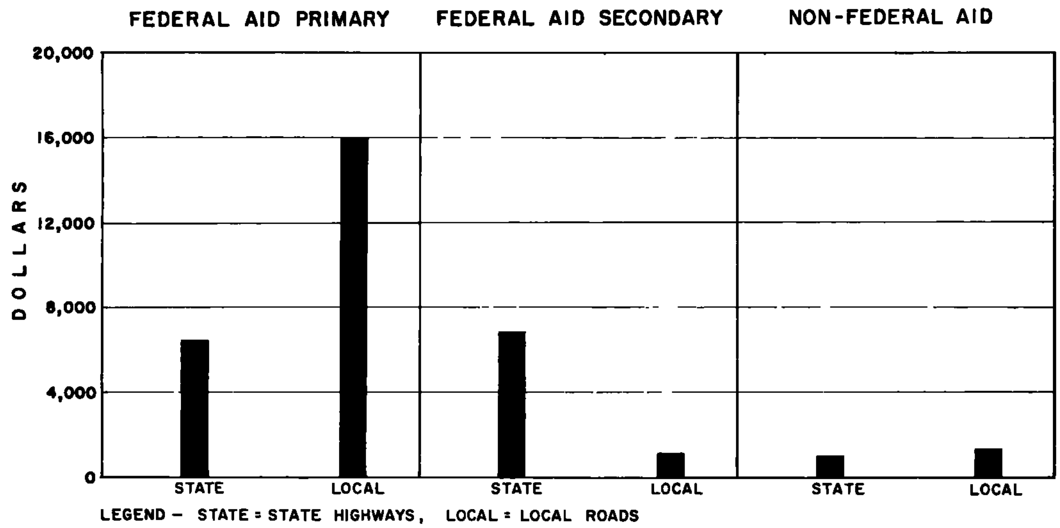


Figure 2. Direct cost of accidents per mile of highway by highway systems.

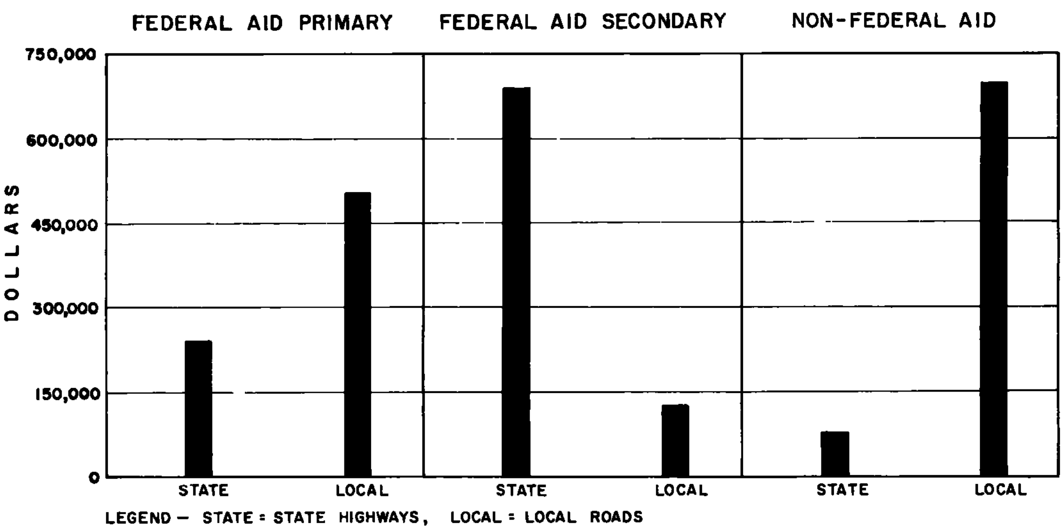


Figure 3. Direct cost of accidents per 100 million vehicle-miles by highway systems.

includes turning movements, parking maneuvers, and backing in traffic lane. The second main grouping includes pedestrian, fixed objects, other objects, and non-collision accidents. Other objects include vehicles such as bicycles, scooters, etc.

In these two groups, 109,730 (84 percent of the total) are two-car accidents while 21,806 (16 percent) are single car accidents. Angle collisions are first in number, rear-end collisions second, other collisions third, and head-on collisions fourth.

A comparison by types of collisions on the six highway systems is also given in Table 10. The percentage breakdowns on the state and local systems are most interesting. While rear-end collisions on each system bear about the same proportion to the total collisions in the system (17 percent on state highways and 17 percent on local roads), angle collisions are more frequent being 23 percent on state highways

TABLE 10

MOTOR-VEHICLE TRAFFIC ACCIDENTS BY TYPE OF ACCIDENT AND HIGHWAY SYSTEM
FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953

	Federal-Aid Primary System		Federal-Aid Secondary System		Non-Federal-Aid System		Total	Total	Total	Total
Type of Accident	State Highway	Local System	State Highway	Local System	State Highway	Local System	Federal-Aid Systems	State Highway	Local Systems	All Systems
Collision with:										
One or more motor-vehicles										
Head-on	2,306	1,462	631	514	15	7,751	4,913	2,952	9,727	12,679
Rear-end	3,403	3,395	864	1,273	15	13,363	8,935	4,282	18,031	22,313
Angle	4,367	7,726	1,276	2,000	15	34,484	15,369	5,658	44,210	49,868
Sideswipe—same direction	1,281	1,070	150	151	-	4,397	2,652	1,431	5,618	7,049
Sideswipe—opposite direction	433	226	15	90	-	708	764	448	1,024	1,472
Other collisions	2,129	1,333	1,086	1,050	181	10,570	5,598	3,396	12,953	16,349
Total	13,919	15,212	4,022	5,078	226	71,273	38,231	18,167	91,563	109,730
Pedestrian	201	327	248	283	30	4,759	1,059	479	5,369	5,848
Fixed objects	745	734	679	726	15	4,361	2,884	1,439	5,821	7,260
Other objects	1,751	875	1,146	153	181	2,358	3,925	3,078	3,386	6,464
Non collision	792	213	577	-	30	622	1,582	1,399	835	2,234
Total	3,489	2,149	2,650	1,162	256	12,100	9,450	6,395	15,411	21,806
Total	17,408	17,361	6,672	6,240	482	83,373	47,681	24,562	106,974	131,536

and 44 percent on the local systems. Pedestrian collisions account for only 2 percent of the collisions on state highways against 5 percent on local roads. Collisions with fixed objects are in about equal proportion, 6 percent on state and 5 percent on local roads.

The costs of the various types of accidents are given in Tables 11 and 12. Table 11 gives total costs and Table 12 gives costs per 100 million vehicle-miles. Table 12 furnishes the data for Figures 4 to 9. These figures show the direct cost of (1) collisions between passenger cars or between passenger cars and other motor vehicles and (2) single car accidents.

An analysis of the results may be made by grouping them into the three main highway systems and comparing the costs per 100 million vehicle-miles on the state highways and on the local roads in each system.

1. Federal-aid primary system.—Figure 4 in the FAP system furnishes a comparison of the costs per 100 million vehicle-miles of each of the six types of collisions in cases where two or more vehicles are involved. Figure 5 gives cost rates of each of the four types of collisions where single-vehicle accidents are involved.

Comparisons are also obtainable on the state and local road systems.

The highest cost rate on the state highways is found in head-on collisions, with rear-end second and angle types third. On local roads the order of cost rates is angle collision first, rear-end second and head-on types third.

In the local road system several types have much higher cost rates than their respective types in the state highway system; that is, angle types, rear-end collisions, fixed object and pedestrian types. The head-on collision cost rate is higher on the state highways.

Reduced to a cost per passenger car-mile basis, the total cost in the FAP system for all types of collisions on the state highways is 0.24 while the local road cost rate is 0.50 cents.

2. Federal-aid secondary system.—Figures 6 and 7 show the cost breakdown by types on the FAS system.

The highest cost on the state highways is in rear-end collisions with angle types second, and "other" types third. The latter include parking maneuvers, backing, and turning movements.

The highest cost on the local roads is in angle types with read-end second, and head-on third.

Cost rates of all types on the state roads exceed those on local roads. In terms of

TABLE 11

DIRECT COSTS OF MOTOR-VEHICLE TRAFFIC ACCIDENTS BY TYPE OF ACCIDENT AND HIGHWAY SYSTEM FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953

Type of Accident	Federal-Aid Primary System		Federal-Aid Secondary System		Non-Federal-Aid System		Total	Total	Total	Total
	State Highway ($)	Local System ($)	State Highway ($)	Local System ($)	State Highway ($)	Local System ($)	Federal-Aid Systems ($)	State Highways ($)	Local Systems ($)	All Systems ($)
Collision with.										
One or more motor-vehicles										
Head-on	3,857,550	958,730	312,490	288,060	36,950	3,513,630	5,416,830	4,206,990	4,760,420	8,967,410
Rear-end	1,745,000	2,140,330	761,900	490,670	20,400	5,561,050	5,137,900	2,527,300	8,192,050	10,719,350
Angle	1,496,100	2,503,180	528,530	658,060	16,500	11,973,340	5,185,870	2,041,130	15,134,580	17,175,710
Sideswipe—same direction	487,980	221,920	83,310	39,640	-	1,104,170	832,850	571,290	1,365,730	1,937,020
Sideswipe—opposite direction	339,850	97,100	43,500	33,040	-	186,460	513,490	383,350	316,600	699,950
Other collisions	452,570	293,600	465,170	186,600	5,430	912,600	1,397,940	923,170	1,392,800	2,315,970
Total	8,379,050	6,214,860	2,194,900	1,696,070	79,280	23,251,250	18,484,880	10,653,230	31,162,180	41,815,410
Pedestrian	150,250	268,980	55,220	62,710	31,500	2,799,550	537,160	236,970	3,131,240	3,368,210
Fixed objects	547,850	670,290	225,310	145,710	35,400	1,395,380	1,589,160	808,560	2,211,380	3,019,940
Other objects	122,350	93,520	194,170	128,900	10,860	135,150	538,940	327,380	357,570	684,950
Non collision	710,030	34,760	333,550	-	2,700	253,950	1,078,340	1,046,280	288,710	1,334,990
Total	1,530,480	1,067,550	808,250	337,320	80,460	4,584,030	3,743,600	2,419,190	5,988,900	8,408,090
Total	9,909,530	7,282,410	3,003,150	2,033,390	159,740	27,835,280	22,228,480	13,072,420	37,151,080	50,223,500

TABLE 12

DIRECT COSTS OF MOTOR-VEHICLE TRAFFIC ACCIDENTS PER 100 MILLION VEHICLE-MILES BY HIGHWAY SYSTEM AND TYPE OF ACCIDENT FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953[1]

Type of Accident	Federal-Aid Primary System		Federal-Aid Secondary System		Non-Federal-Aid System		Total	Total	Total	Total
	State Highway ($)	Local System ($)	State Highway ($)	Local System ($)	State Highway ($)	Local System ($)	Federal-Aid Systems ($)	State Highways ($)	Local Systems ($)	All Systems ($)
Collision with:										
One or more motor-vehicles										
Head-on	95,768	66,904	72,002	18,430	17,266	88,818	72,631	89,970	68,476	77,119
Rear-end	43,322	149,360	175,553	31,393	9,533	140,573	68,891	54,048	117,837	92,186
Angle	37,142	174,681	121,781	42,102	7,710	302,663	69,535	43,651	217,701	147,710
Sideswipe—same direction	12,115	15,486	19,196	2,536	-	27,911	11,167	12,218	19,645	16,658
Sideswipe—opposite direction	8,437	6,776	10,023	2,114	-	4,713	6,885	8,198	4,554	6,020
Other collisions	11,236	20,489	107,182	11,939	2,538	23,069	18,744	19,743	20,035	19,917
Total	208,020	433,696	505,737	108,514	37,047	587,747	247,853	227,828	448,248	359,610
Pedestrian	3,730	18,770	12,723	4,012	14,720	70,767	7,203	5,068	45,041	28,966
Fixed objects	13,601	46,775	51,915	9,322	16,542	35,273	21,308	17,292	31,809	25,971
Other objects	3,038	6,526	44,740	8,247	5,075	3,416	7,226	7,001	5,143	5,891
Non collision	17,627	2,426	76,855	-	1,261	6,419	14,459	22,375	4,153	11,481
Total	37,996	74,497	186,233	21,581	37,598	115,875	50,196	51,736	86,146	72,309
Total	246,016	508,193	691,970	130,095	74,645	703,622	298,049	279,564	534,394	431,919

[1] Derived from Tables 5 and 11.

cost per passenger car-mile, the total cost in the FAS system on state roads was 0.69 cents as compared with 0.13 cents on local roads.

3. Non-Federal-aid system.—Figures 8 and 9 show the cost breakdown by types on the NFA system.

The highest cost on the state highways is in fixed object cases with pedestrian accidents second.

The highest cost on the local roads is in angle types and amounts to $302,663 per 100 million vehicle-miles. This, incidentally, exceeds the figures on any type in any highway system by a wide margin. Second in cost-rate are rear-end types, third head-on, and fourth pedestrian accidents. In comparing costs in each of the two highway subdivisions in the NFA system, it should be stressed that the mileage on the state roads is only 155 while that on the local roads is 20,197.

The cost per passenger car-mile in the NFA system on the state roads is 0.07 cents while the cost per passenger car-mile on the local roads is 0.70 cents.

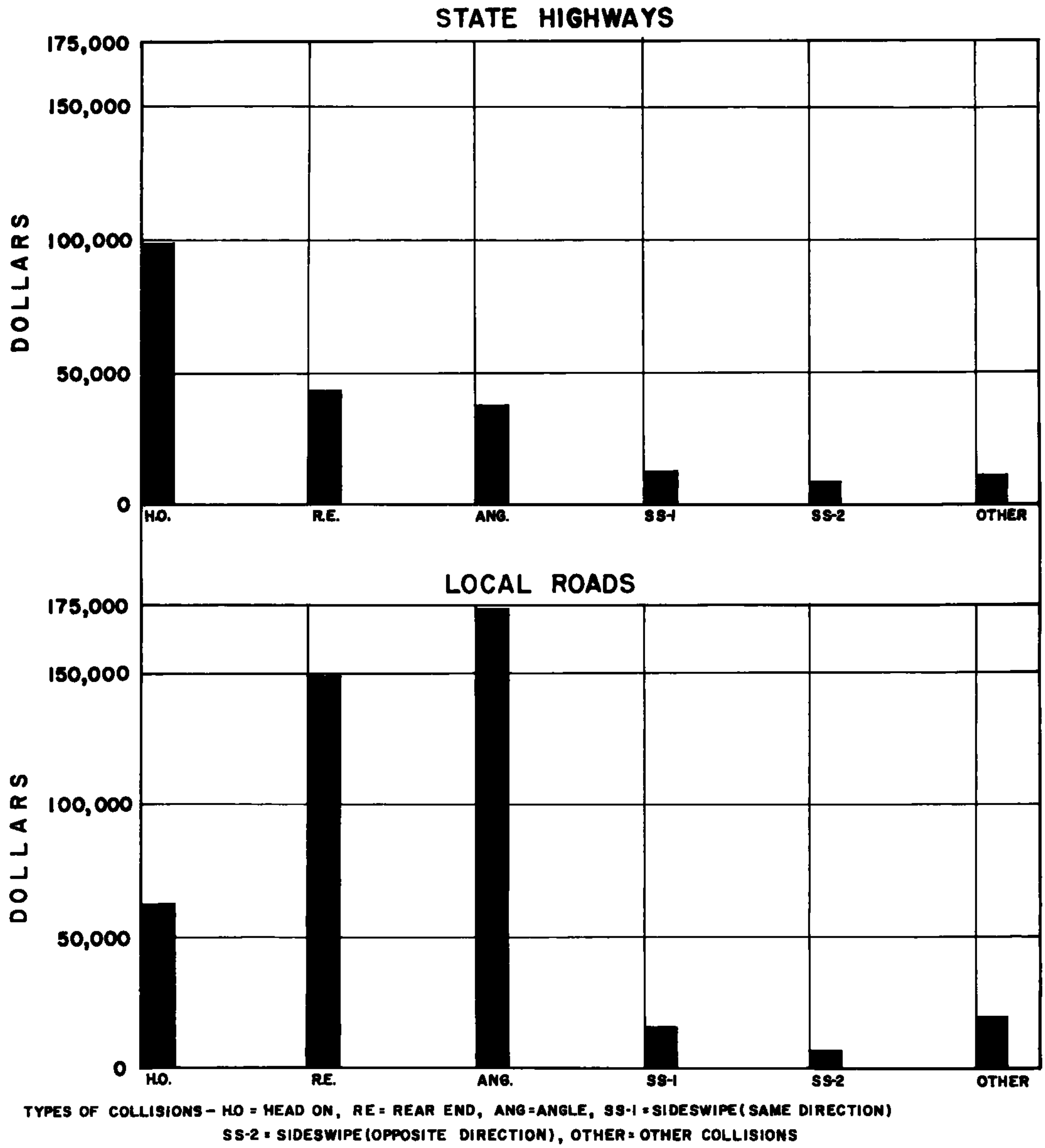


Figure 4. Federal-aid primary system— direct cost per 100 million vehicle-miles of collisions between: (a) passenger cars, and (b) passenger cars and other motor vehicles.

ECONOMIC COSTS ON SELECTED SECTIONS OF STATE HIGHWAYS IN MASSACHUSETTS

In the analysis of the accident records and economic costs on the six highway systems a general picture has been obtained on a statewide basis. To get an idea of the economic costs on specific sections of highway it may be of interest to consider the results contained in an Accident Rate and Cost Study prepared in 1957. This study was based on the accidents reported to the Registrar of Motor-Vehicles in 1955. The purpose of the study was to determine the direct costs of accidents on two types of state highways; namely, those having no control of access and those on which access was controlled. Four highways were selected of the former type and they included

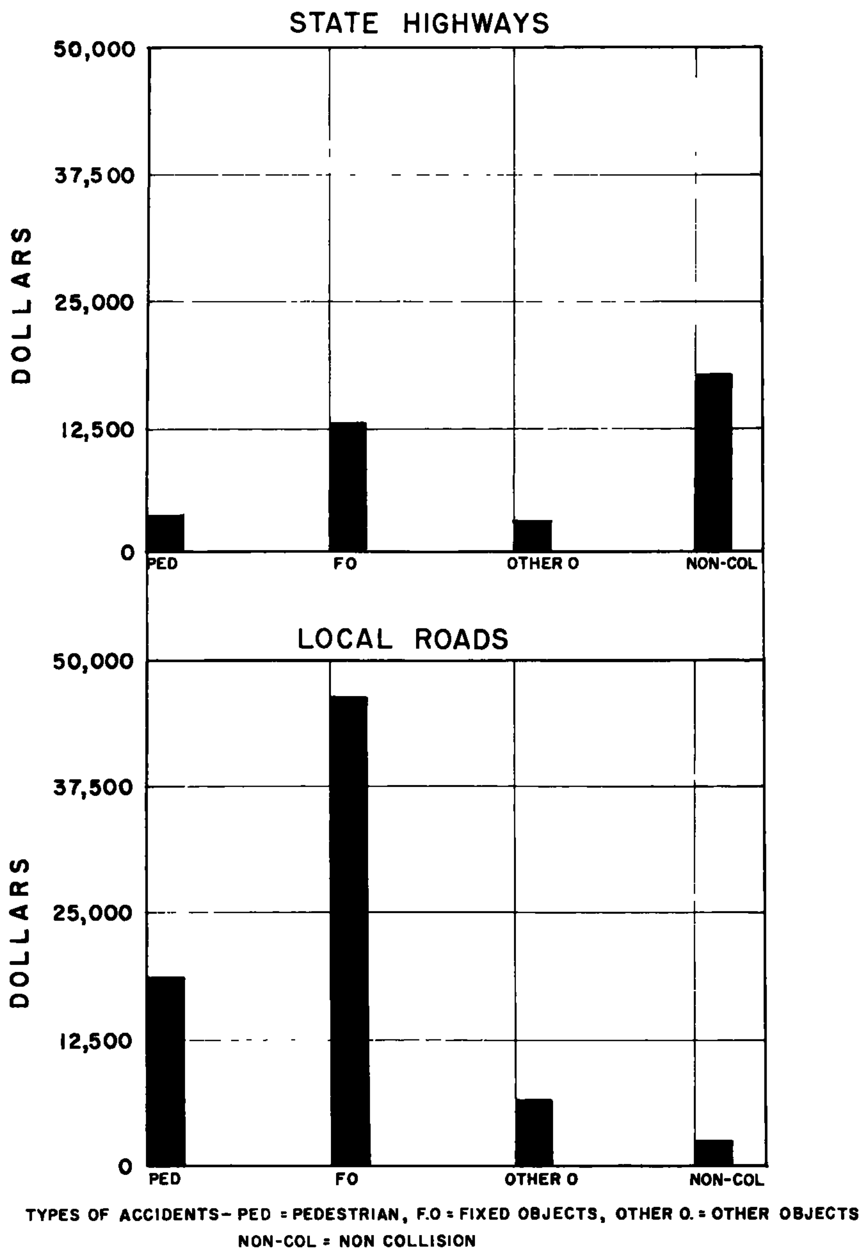


Figure 5. Federal-aid primary system—direct cost per 100 million vehicle-miles of single car accidents (passenger cars only).

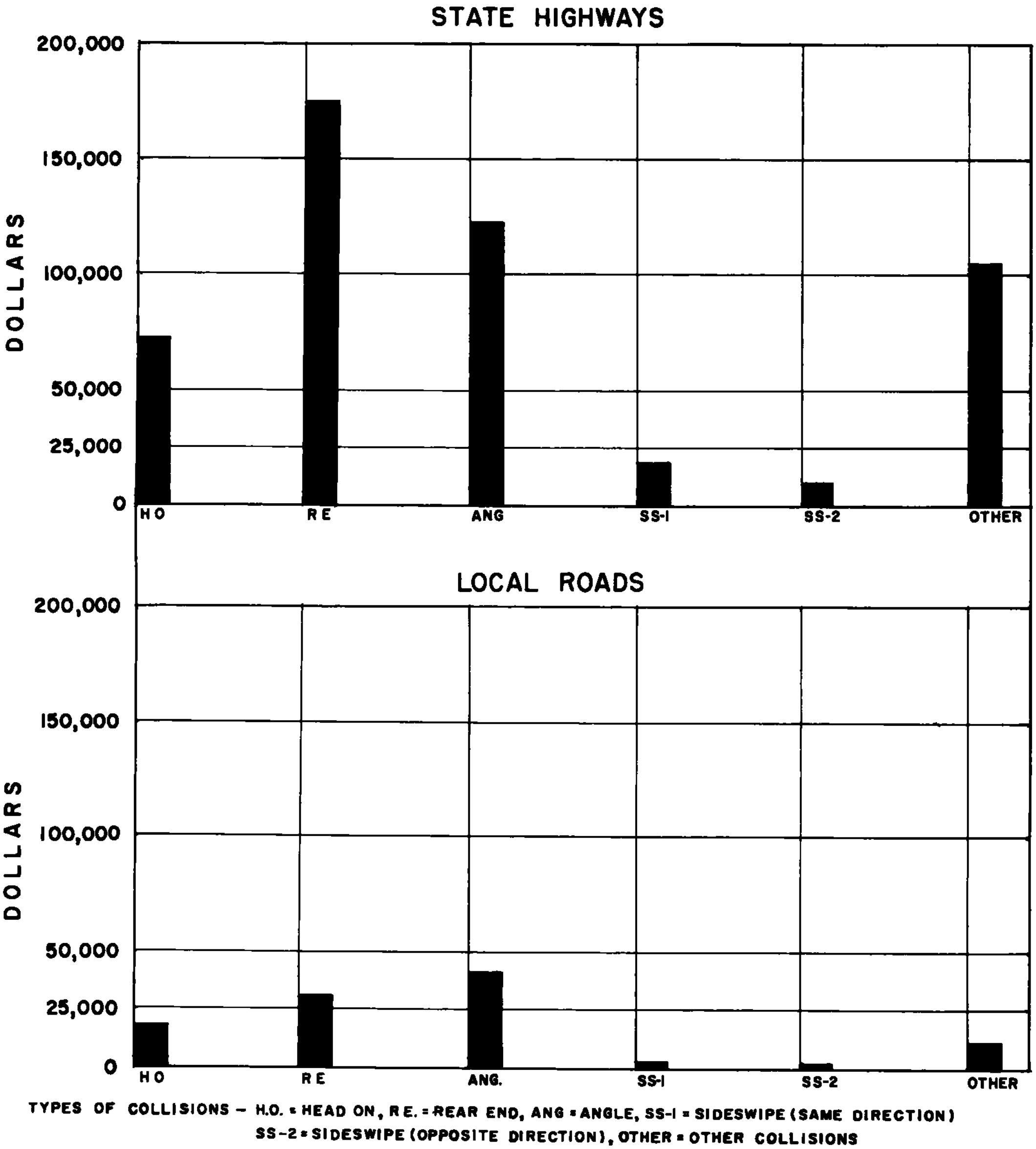


Figure 6. Federal-aid secondary system—direct cost per 100 million vehicle-miles of collisions between: (a) passenger cars, and (b) passenger cars and other motor vehicles.

2-, 3-, 4- and 6-lane roads. Five highways were of the latter type and all of these were 4-lane divided roads which had been opened to traffic since June 1952. As part of the study, two curves (Fig. 10) were prepared by plotting the yearly accident cost per mile against traffic volume (ADT) for each of the nine sections of highway. The costs used were based on the results of the Massachusetts Accident Cost Study and were direct costs only. This chart shows a yearly saving in cost of accidents per mile of highway of $18,000 at 10,000 vehicles per day and $68,000 at 25,000 vehicles per day on the controlled-access roads.

It was pointed out in the study that because this was an initial attempt, future studies

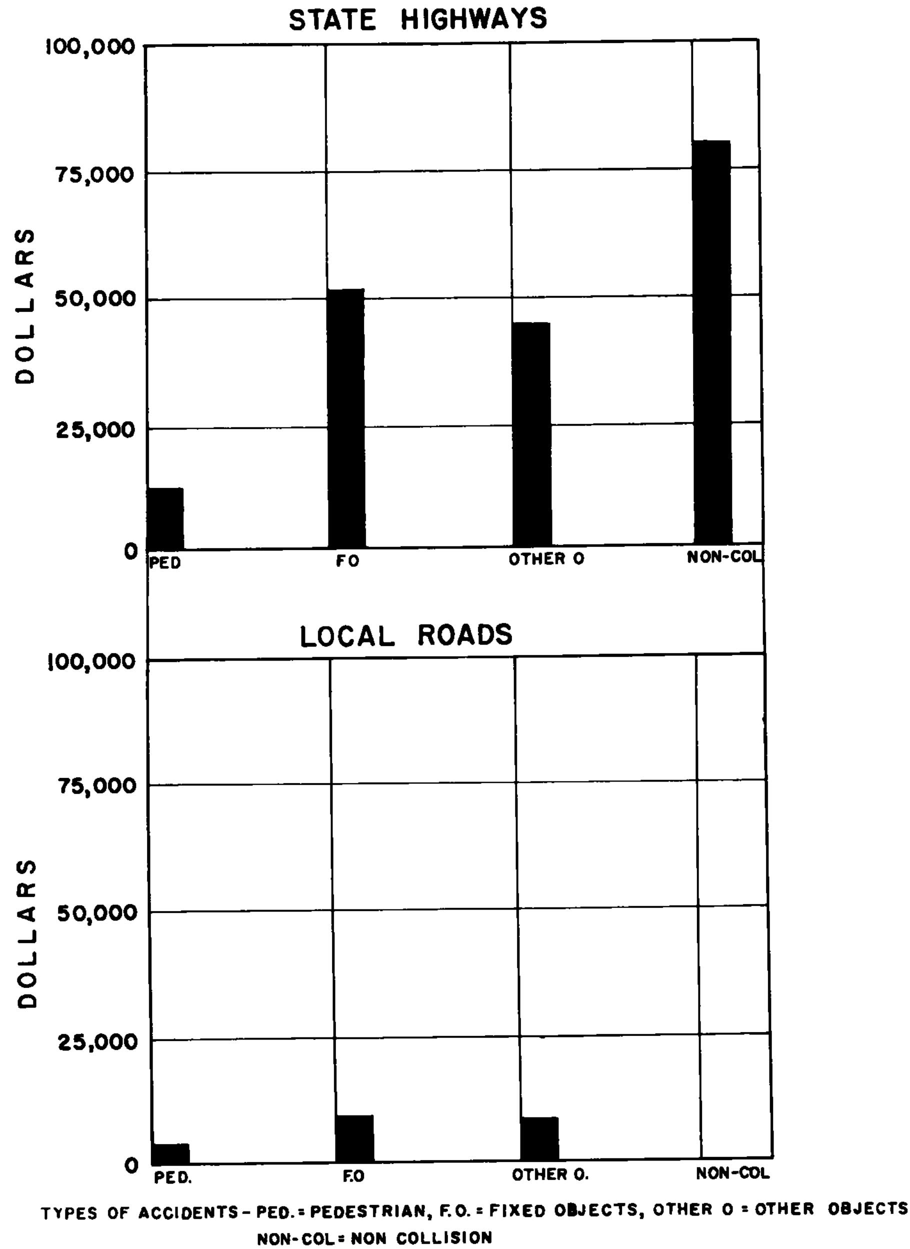


Figure 7. Federal-aid secondary system—direct cost per 100 million vehicle-miles of single car accidents (passenger cars only).

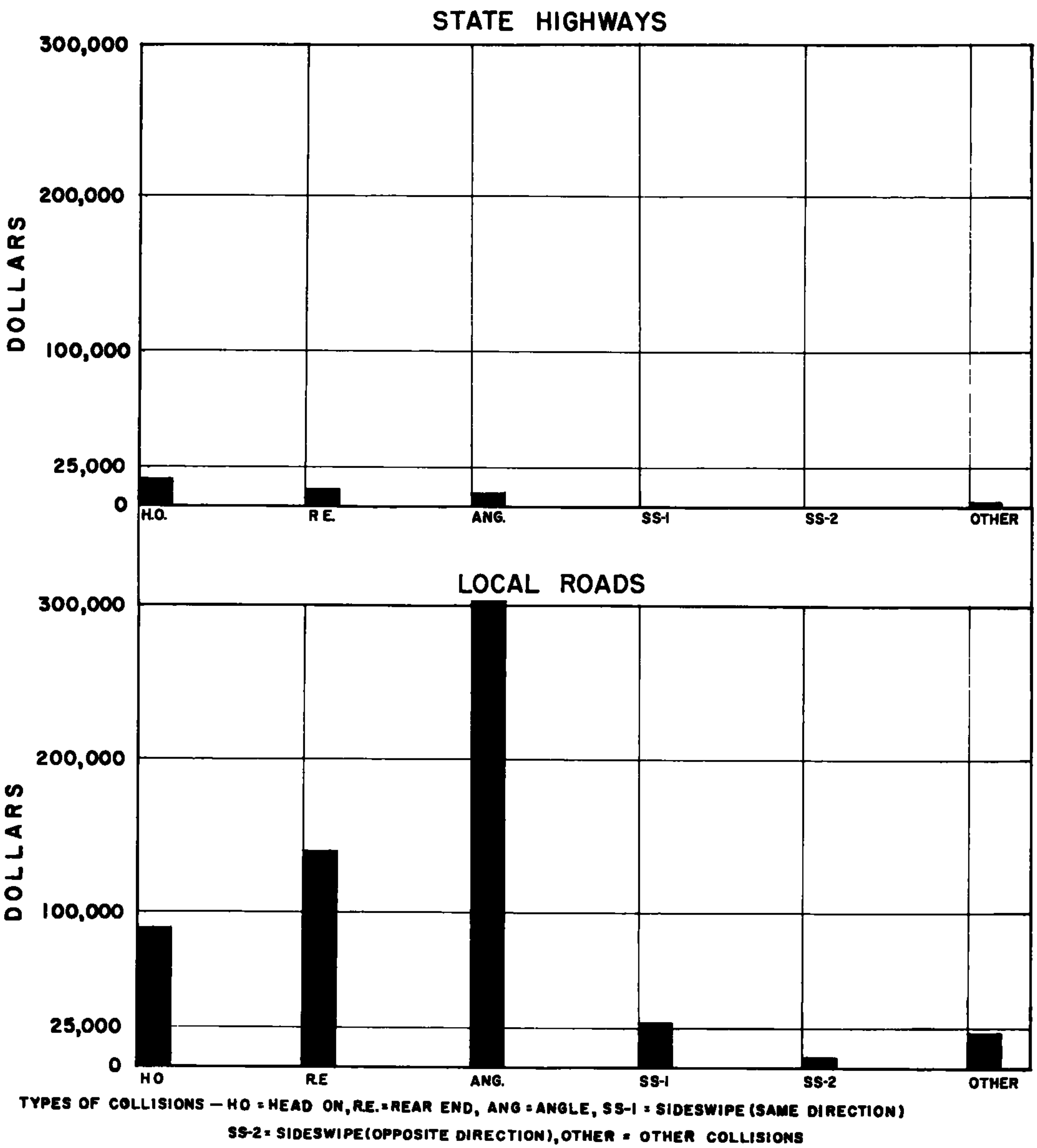


Figure 8. Non-Federal-aid system—direct cost per 100 million vehicle-miles of collisions between: (a) passenger cars, and (b) passenger cars and other motor vehicles.

might alter the results obtained. Since this study was completed, a new comparison of accident costs on eight of the nine highways has become available and the figures are given in Table 13. The 1957 records of accidents submitted to the Registry are used in this table. A comparison of the results in accident costs per mile with the curves in Figure 10 proved to be of special interest inasmuch as volumes on the highways had changed since 1955. In one case—Route 20-2, the so-called Southwest Connection—volumes had decreased substantially because of the opening of the Massachusetts Turnpike. Its accident cost per mile versus the new volume figure agrees quite closely with the curve.

Figures on the other highways are likewise quite consistent with the curves with

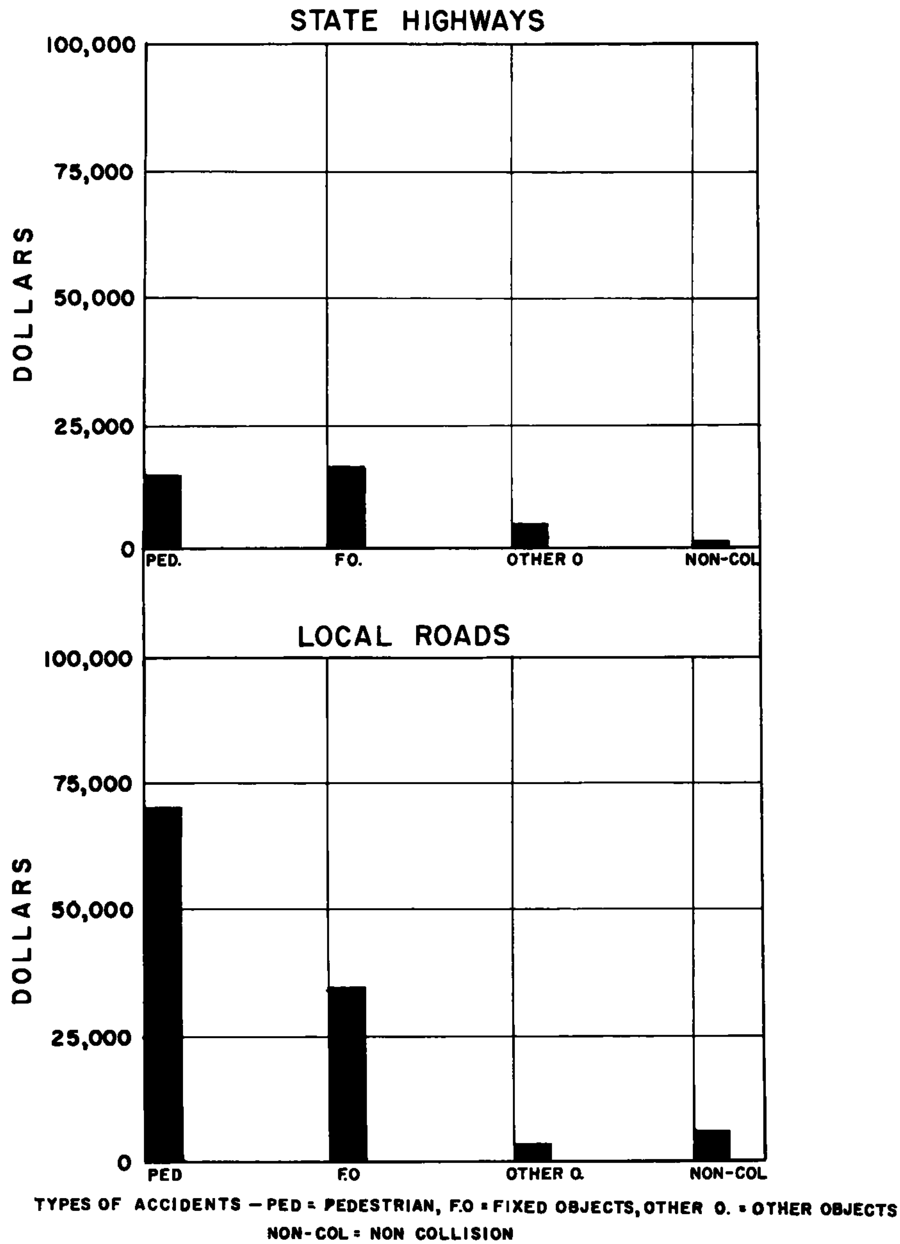


Figure 9. Non-Federal-aid system—direct cost per 100 million vehicle-miles of single car accidents (passenger cars only).

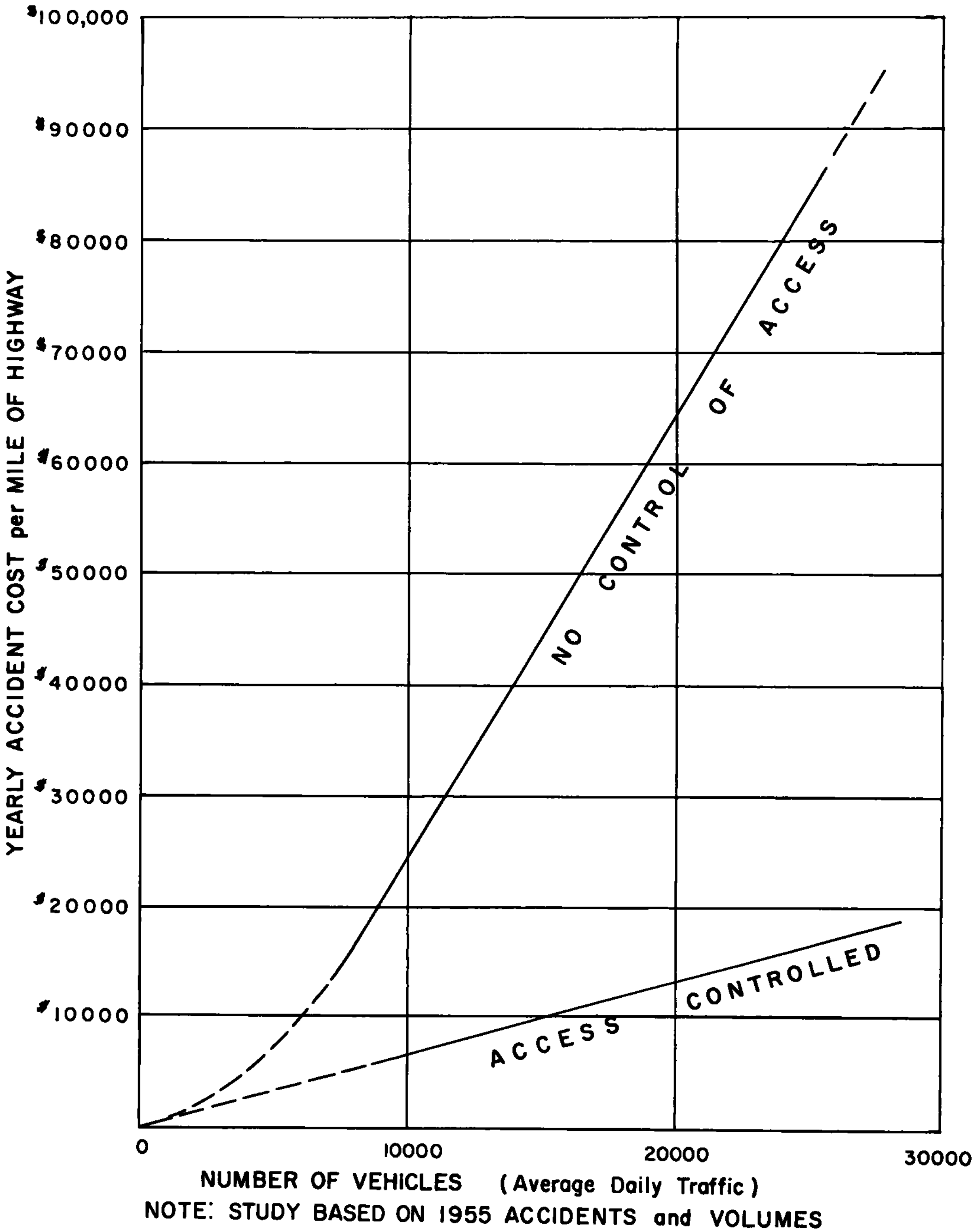


Figure 10. Accident costs on state highways with no control of access and with access controlled.

TABLE 13

ACCIDENT RATES AND COSTS ON STATE HIGHWAYS IN MASSACHUSETTS COMPARING ACCESS-CONTROLLED ROADS WITH ROADS WITH NO CONTROL OF ACCESS: 1957

Sections of State Highway	Miles	Volume ADT	Killed	Fatal Accidents	Non-Fatal Personal-Injury Accidents	Property-Damage Accidents	Total Accidents	Persons Injured	100 MVM Accidents*	Direct Costs Per Mile
Roads with Access Controlled										
Route 128 (Wellesley to Lynnfield)	24.6	32,200	3	3	254	211	468	495	161.7	$ 30,100
Route 15 (Sturbridge to Holland)	6.7	15,700	2	2	26	17	45	50	117.2	13,900
Route 2 (Concord to Westminster)	29.4	7,600	8	4	43	58	105	117	128.7	7,250
Route 1 (Danvers to Salisbury)	21.6	15,500	5	5	86	68	159	200	130.1	14,800
Total	82.3	17,700**	18	14	409	354	777	862	146.2	
Roads with No Control of Access										
Route 1 (Revere to Peabody)	7.8	30,900	5	3	213	109	325	420	370.5	79,700
Route 20-1 (Northboro to Weston)	20.5	8,200	1	1	72	68	141	119	230.2	9,700
Route 20-2 (Northboro to Auburn)	15.9	8,600	3	2	122	82	206	213	412.7	21,600
Route 9 (Brookline to Framingham)	19.9	30,400	8	6	572	339	917	1,018	415.3	78,500
Total	64.1	17,900**	17	12	979	598	1,589	1,770	378.4	

* Accidents per 100 million vehicle-miles.
** Weighted average.

one exception. In the volume range above 25,000 vehicles per day there is some variation from the 1955 curves. Values on the uncontrolled-access roads were somewhat lower than the curve in this volume range. One explanation for this may be that the overcrowding of the free-access roads actually tends to prevent certain types of collisions.

Only one example of a controlled-access highway in this high volume range was available. This was Route 128 north, a section of the Northern Circumferential Highway. This road, though opened in 1952, has been reaching capacity and it is now being widened and modernized. Its accident rate was 161.7 accidents per 100 million vehicle-miles in 1957. This was twice its rate in 1953. Its accident cost per mile had increased from $19,100 in 1955 to $30,100 in 1957. When reconstructed, this section of Route 128 should, without doubt, reverse this upward trend.

In summation, it may be stated that the low accident rates and costs on the controlled-access highways are consistent with previous findings and that they most certainly contribute their part in maintaining a comparatively low accident rate on the state highways in the FAP system.

CONCLUSION

This study emphasizes the immediate need for action through accident prevention on all highway systems in Massachusetts.

Local roads in the NFA system deserve special consideration in the urban areas. Because many accidents are occurring in the cities of the Commonwealth this problem should be given special attention.

In the FAP system, state highways have a decidedly lower average accident rate than that on the local roads. Nevertheless, both represent large economic losses sustained through highway accidents.

In the FAS system, the state highways have a high accident rate and also involve high economic losses.

On the brighter side, it is evident that in the state highway system, the highways with full control of access experience much lower accident rates, at a given volume, than do those highways where access is uncontrolled. Economic losses are also comparatively low on the controlled-access roads.

In summary then, this study indicates the need for accelerated efforts in accident prevention from the viewpoint of reducing personal injuries and economic losses as well. In addition, it pinpoints the highway systems where, through road construction and reconstruction, traffic control, enforcement and other means, remedial measures should be given priority.

Economic Cost of Traffic Accidents in Relation to the Vehicle

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This paper discusses accidents in Massachusetts in which Massachusetts registered vehicles were involved and the resulting economic costs. The data were developed by the Massachusetts Department of Public Works and the Registry of Motor Vehicles in cooperation with the U. S. Bureau of Public Roads. It covers the involvements of passenger cars in traffic accidents during 1953 and the involvements of trucks in traffic accidents during 1955. The purpose is to present the cost of accidents in relation to the vehicle in a way that will be helpful both to those interested in pinpointing where prevention efforts should be centered and to those engaged in the economic analysis of highway improvements. It is not the purpose to fix the responsibility for accidents by type of vehicle but rather to show what kinds of vehicles were involved and the extent of the involvement in terms of cost.

Involvement and cost data are analyzed separately for passenger cars and trucks by age of vehicle and severity of accident. Further analyses are made of trucks involved in accidents and their direct costs in relation to the registered gross weight and type of truck. Comparisons are made throughout the report on the basis of the involvements per 100 million vehicle-miles and the accident cost per vehicle-mile.

An involvement is one vehicle in one accident. For example, in the passenger car study if a passenger car hit a pedestrian there was 1 involvement in 1 accident. If 2 passenger cars collided with each other there were 2 involvements in 1 accident. Also, in the passenger car study if a passenger car collided with a truck this was 1 passenger car involvement in 1 accident. The truck involvement was not included in the passenger car study.

OVER-ALL ACCIDENT EXPERIENCE

●THERE WERE 1,239,596 passenger cars and 179,610 trucks registered in Massachusetts during 1953 and 1955, respectively. Table 1 shows that passenger cars were driven 11.6 billion vehicle-miles and that trucks were driven about 2 billion vehicle-miles. The truck mileage was about 17 percent of the miles driven by passenger cars. The direct cost of passenger car accidents was $50,223,500 as compared to a truck accident cost of $4,773,590. The cost attributable to trucks was about 9.5 percent of the cost of passenger cars. These direct costs consist of the money value of damage to property, medical costs resulting from injuries to persons, value of time lost, loss of use of motor vehicle, legal and court costs, damages awarded in excess of costs,

TABLE 1

NUMBER OF VEHICLES REGISTERED IN MASSACHUSETTS (PASSENGER CARS, 1953, AND TRUCKS, 1955) AND THEIR TRAVEL, CLASSIFIED BY AGE OF VEHICLE

Age of Vehicle (yr)	Number of Vehicles	Percent of Total	Vehicle Travel: Total Mileage (thousands)	Vehicle Travel: Percent of Total	Vehicle Travel: Average Annual Mileage
(a) Passenger Cars Registered in 1953					
Under 2	257,852	20.8	3,331,000	28.6	12,918
2 - 4	333,947	26.9	3,390,000	29.2	10,151
4 - 8	356,030	28.7	3,143,000	27.0	8,828
8 and older	291,767	23.6	1,764,000	15.2	6,046
Total	1,239,596	100.0	11,628,000	100.0	9,380
(b) Trucks Registered in 1955					
Under 2	27,074	15.1	354,737	17.4	13,102
2 - 4	27,343	15.2	395,707	19.4	14,472
4 - 8	67,913	37.8	794,942	39.0	11,705
8 and older	57,280	31.9	494,710	24.2	8,637
Total	179,610	100.0	2,040,096	100.0	11,358

and miscellaneous items. All of these cost elements usually are involved in the cost of fatal or non-fatal injury accidents. In property-damage-only accidents there are no medical expenses.

In addition to the total direct costs of traffic accidents just described there were other direct costs in connection with non-traffic accidents, traffic incidents and non-traffic incidents that are not covered in this report. Non-traffic accident involvements—accidents involving motion but not occurring on a public roadway—resulted in additional direct costs of $2,698,000 for passenger cars and $327,000 for trucks. Traffic incidents—mishaps on public roads but not involving motion and usually involving either vandalism, fire, or Acts of God—resulted in direct costs of $2,361,000 for passenger cars and $276,000 for trucks. Non-traffic incidents—mishaps not on public roads and not involving motion and usually involving either vandalism, fire, or Acts of God—resulted in direct costs of $2,327,000 for passenger cars and $589,000 for trucks. This analysis is confined to the $50,223,500 for passenger cars and $4,773,590 for trucks which comprise the direct costs of motor-vehicle traffic accidents in Massachusetts.

It is evident that trucks have an appreciably lower over-all accident cost per mile. The cost per mile was 0.23 cents for trucks and 0.43 cents for cars. Comparsion of the cost of accidents by severity (Fig. 1) shows that the direct cost of operating a passenger car 1 mi was 0.17 cents for property-damage-only accidents while for trucks in similar accidents it was 0.07 cent. For non-fatal injury accidents it was 0.25 cent per mile of passenger car operation and 0.14 cent per mile of truck operation. Only for the fatal-injury accidents was the rate for trucks higher, being 0.014 cent for passenger cars and 0.027 cent for trucks for each mile of vehicle operation.

It should be noted that for fatal-injury accidents, the cost per mile for cars is almost one-half that for trucks but that for non-fatal-injury accidents and property-damage-only accidents the cost per passenger car mile of travel is about 2½ and 2 times that for trucks. These last two classes of accidents account for by far the greater part of the cost of accidents.

Figure 2 compares the average cost per involvement of passenger cars and trucks.

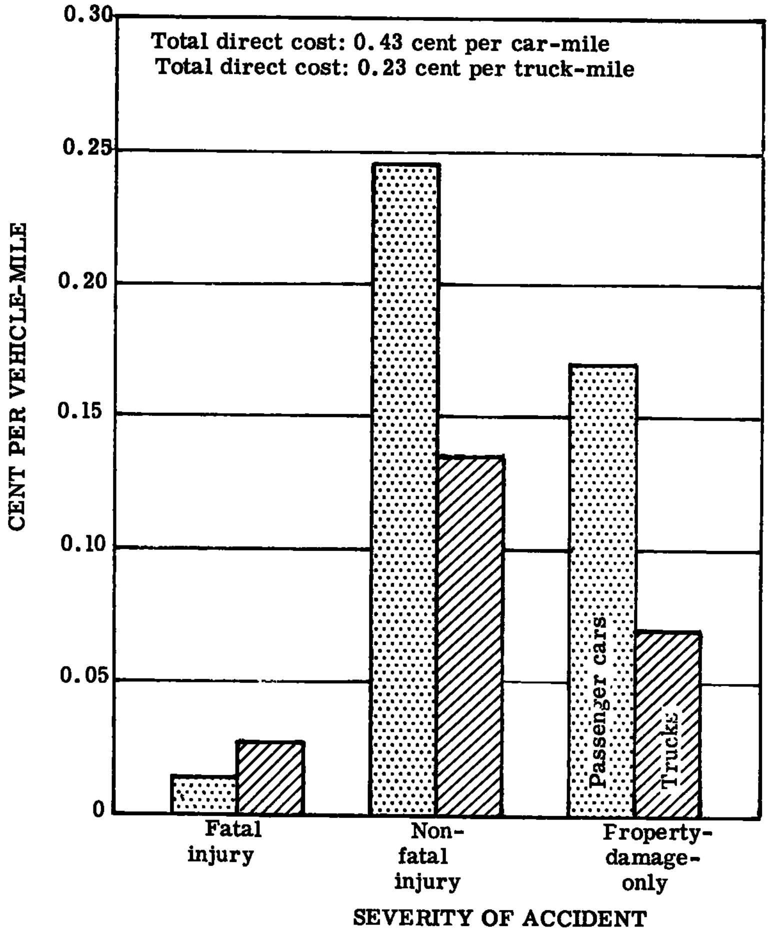

Figure 1. Direct cost of traffic accidents in Massachusetts per passenger-car-mile of travel during 1953, and per truck-mile of travel during 1955, classified by severity of accident.

The average cost per passenger car involvement was 27 percent more than the cost per truck involvement. This average cost for all involvements was heavily influenced by the fact that property-damage-only involvements account for the largest percentage of all accidents. It was because the average cost of truck involvements in property-damage-only accidents was only one-half that of passenger cars that trucks had a lower average cost per involvement in the case of all accidents. This was true even through the average cost of truck involvements was 43 percent higher for fatal-injury involvements and 16 percent higher for non-fatal-injury involvements than were the costs of similar involvements for passenger cars.

AGE OF VEHICLE

Table 2 summarizes the number of cars involved in accidents and the involvement rates by age of car and severity of accident. Similar data for trucks are given in Table 3. For purposes of orientation on involvements and accidents, 222,059 passenger cars were involved in 131,536 accidents. This total is comprised of 344 involvements in 315 fatal accidents, 54,260 involvements in 33,270 non-fatal-injury accidents, and 167,455 involvements in 97,951 property-damage-only accidents.

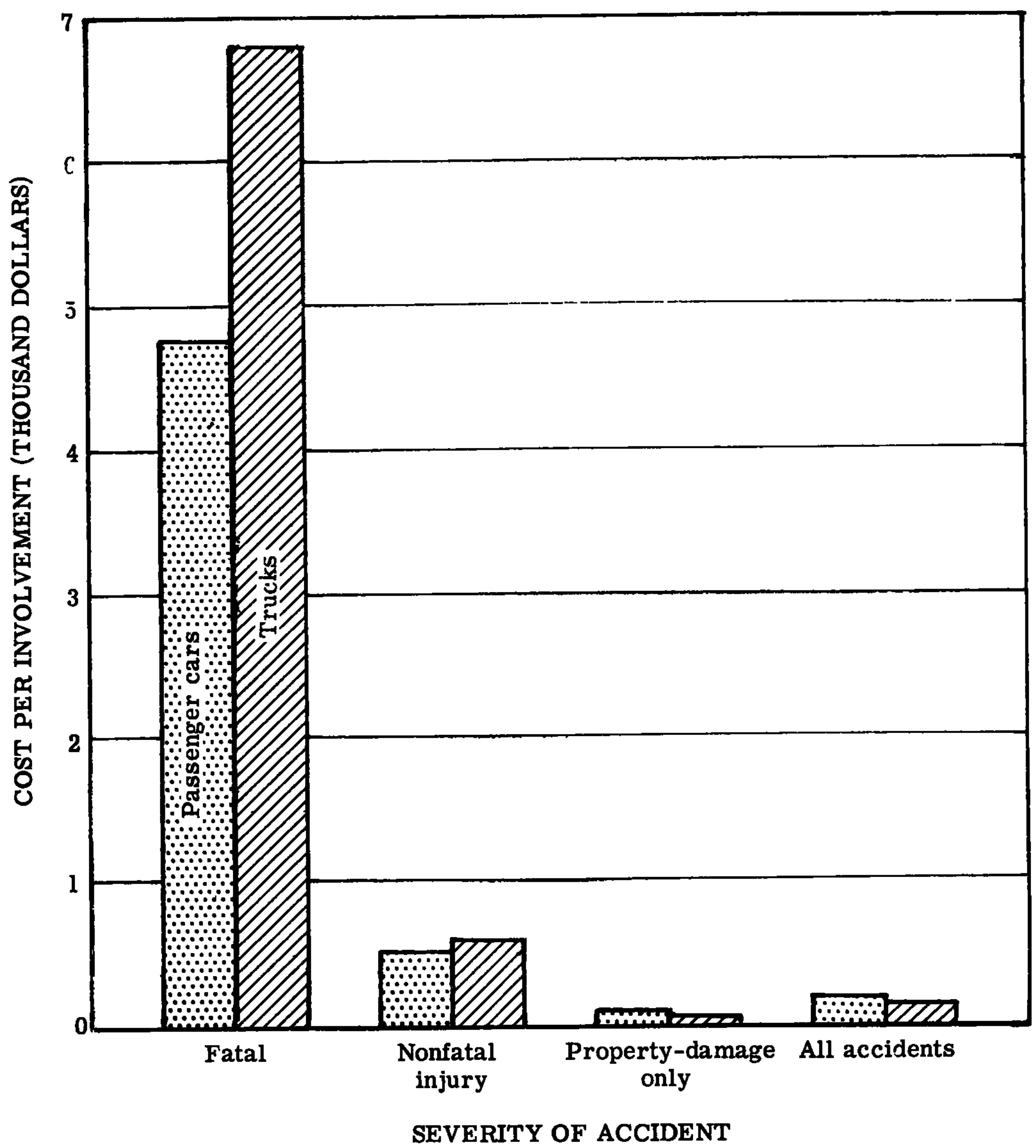

Figure 2. Comparison of the average cost of involvements for passenger cars and trucks.

TABLE 2

NUMBER OF PASSENGER CARS INVOLVED IN MOTOR-VEHICLE TRAFFIC ACCIDENTS AND THE RATE PER 100 MILLION PASSENGER-CAR MILES, CLASSIFIED BY AGE OF CAR AND SEVERITY OF ACCIDENT

Age of Passenger Car (yr)	Passenger Cars Involved in								Number of Passenger Cars per 100 Million Passenger-Car Miles of Travel Involved in·			
	Fatal-Injury Accident		Non-Fatal-Injury Accidents		Property-Damage-Only Accidents		All Accidents		Fatal-Injury Accidents	Non-Fatal-Injury Accidents	Property Damage-Only Accidents	All Accidents
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total				
Under 2	66	19.2	10,403	19.2	31,162	18.6	41,631	18.7	2.0	312	936	1,250
2 - 4	94	27.3	15,311	28.2	47,375	28.3	62,780	28.3	2.8	452	1,397	1,852
4 - 8	101	29.4	16,762	30.9	51,927	31.0	68,790	31.0	3.2	533	1,652	2,189
8 and older	83	24.1	11,784	21.7	36,991	22.1	48,858	22.0	4.7	668	2,097	2,770
Total	344	100.0	54,260	100.0	167,455	100.0	222,059	100.0	3.0	467	1,440	1,910

TABLE 3

NUMBER OF TRUCKS INVOLVED IN MOTOR-VEHICLE TRAFFIC ACCIDENTS AND THE RATE PER 100 MILLION TRUCK-MILES, CLASSIFIED BY AGE OF TRUCK AND SEVERITY OF ACCIDENT

Age of Truck (yr)	Trucks Involved in: Fatal-Injury Accidents		Non-Fatal-Injury Accidents		Property-Damage-Only Accidents		All Accidents		Number of Trucks per 100 Million Truck-Miles of Travel Involved in:			
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Fatal-Injury Accidents	Non-Fatal-Injury Accidents	Property-Damage-Only Accidents	All Accidents
Under 2	19	23.2	705	15.6	4,080	16.9	4,804	16.7	5.4	200	1,150	1,355
2 - 4	13	15.9	959	21.3	4,749	19.6	5,721	19.9	3.3	242	1,200	1,466
4 - 8	28	34.1	1,881	41.7	9,395	38.8	11,304	39.2	3.5	237	1,182	1,442
8 and older	22	26.8	964	21.4	5,981	24.7	6,967	24.2	4.4	195	1,209	1,408
Total	82	100.0	4,509	100.0	24,205	100.0	28,796	100.0	4.0	223	1,186	1,412

In contrast, 28,796 trucks were involved in 27,041 accidents during 1955. Classified by severity there were 82 involvements in 77 fatal accidents, 4,509 involvements in 4,344 non-fatal-injury accidents, and 24,205 involvements in 22,648 property-damage-only accidents. The ratio of truck involvements to accidents is almost 1.1 to 1 (28,796 to 27,041), whereas the corresponding ratio for passenger cars was 1.7 to 1 (222,059 to 131,536).

The influence of age on the involvement rates of passenger cars and trucks is shown in Figure 3 for all accidents. In the case of passenger cars the rate increased steadily with age. The rate for passenger cars, 8 years and older, was more than twice that for cars under 2 years of age. This can be construed as a strong argument for vehicle inspection even though there are factors other than mechanical condition contributing to the situation. With respect to involvement rates, trucks appear to be ageless, there being no significant trend upward with age. Although the involvement rate for passenger

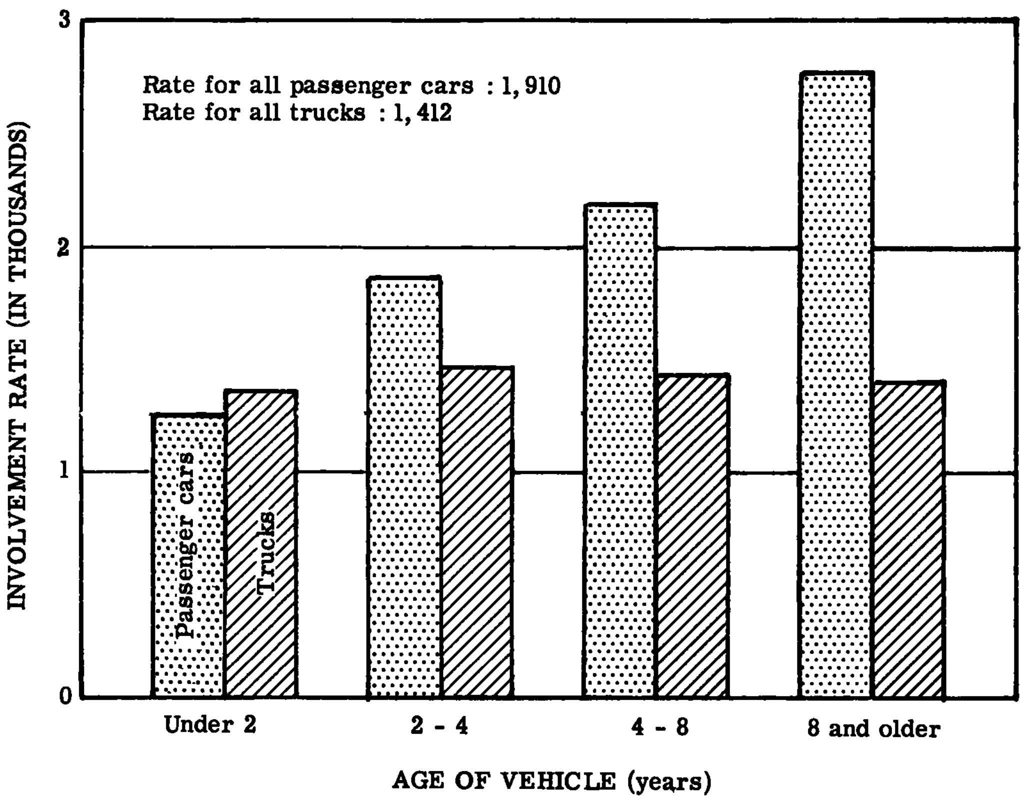

Figure 3. Comparison of involvement rates per 100 million vehicle-miles of travel for passenger cars and trucks by age of vehicle.

cars is generally higher than that for trucks, the rates are approximately the same for the group of vehicles under 2 years of age.

The characteristic of age established in Figure 3 for all accidents holds for all the severity classes except for the fatal-injury accidents. Throughout the report it will be seen that this class of accident has distinct characteristics in relation to the other two classes. Because of the difference, the fatal-injury class is considered separately in Figure 4. Just as for all accidents, the fatal involvement rate for passenger cars increased with age. The difference was that the fatal involvement rate for trucks also increased with age, if the vehicles under 2 years of age are ignored. An important point is that the fatal rate for trucks is almost 3 times that for passenger cars for the vehicles less than 2 years of age. For other than the newest age group, the great difference in involvement rate between passenger cars and trucks observed in Figure 3 for all accidents is not evident for the fatal involvement. It is to be kept in mind that the number of fatal-injury accidents in proportion to the total is so small that their effect on the involvement rate or costs per mile for all accidents is very insignificant.

The relationship between accident cost per vehicle-mile and age of vehicle for each severity class of accident and for all accidents is shown in Figure 5 for passenger cars, and in Figure 6 for trucks. A comparison of the two figures which are drawn to the

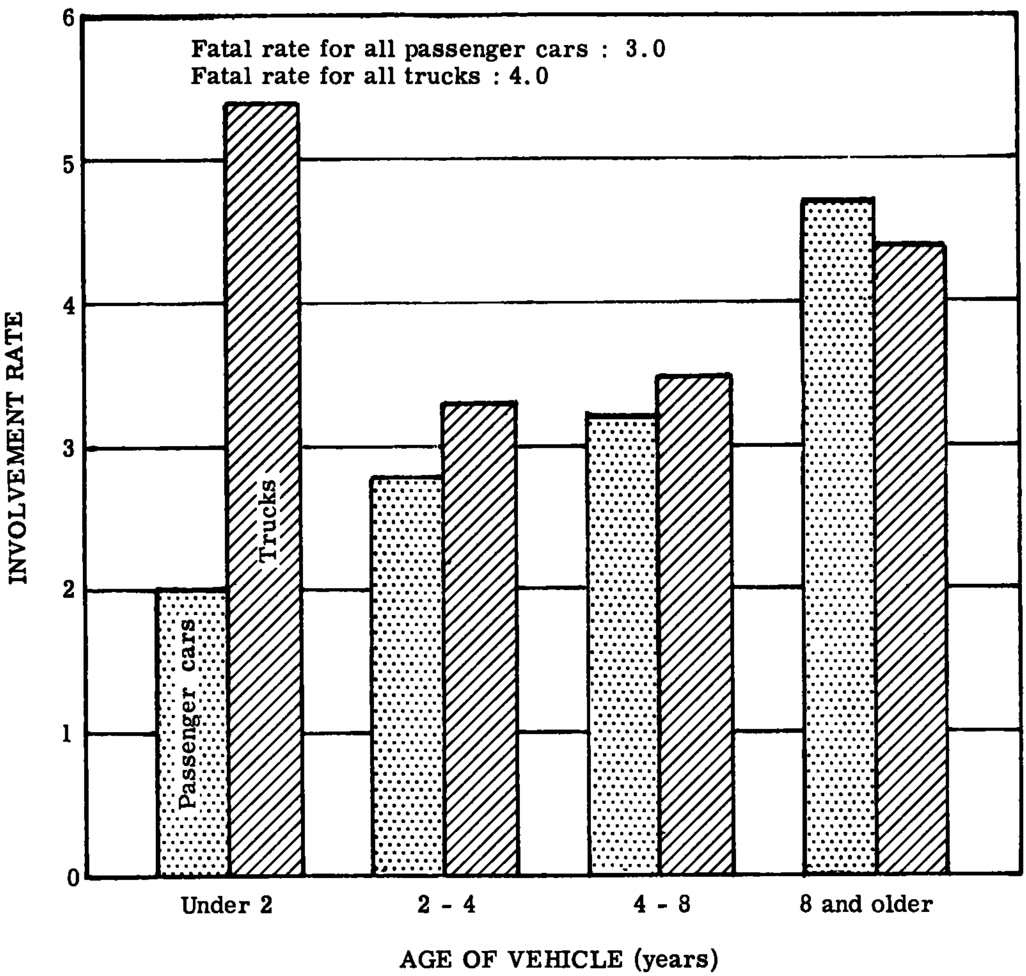

Figure 4. Comparison of fatal-injury accident involvement rates per 100 million vehicle-miles of travel for passenger cars and trucks by age of vehicle.

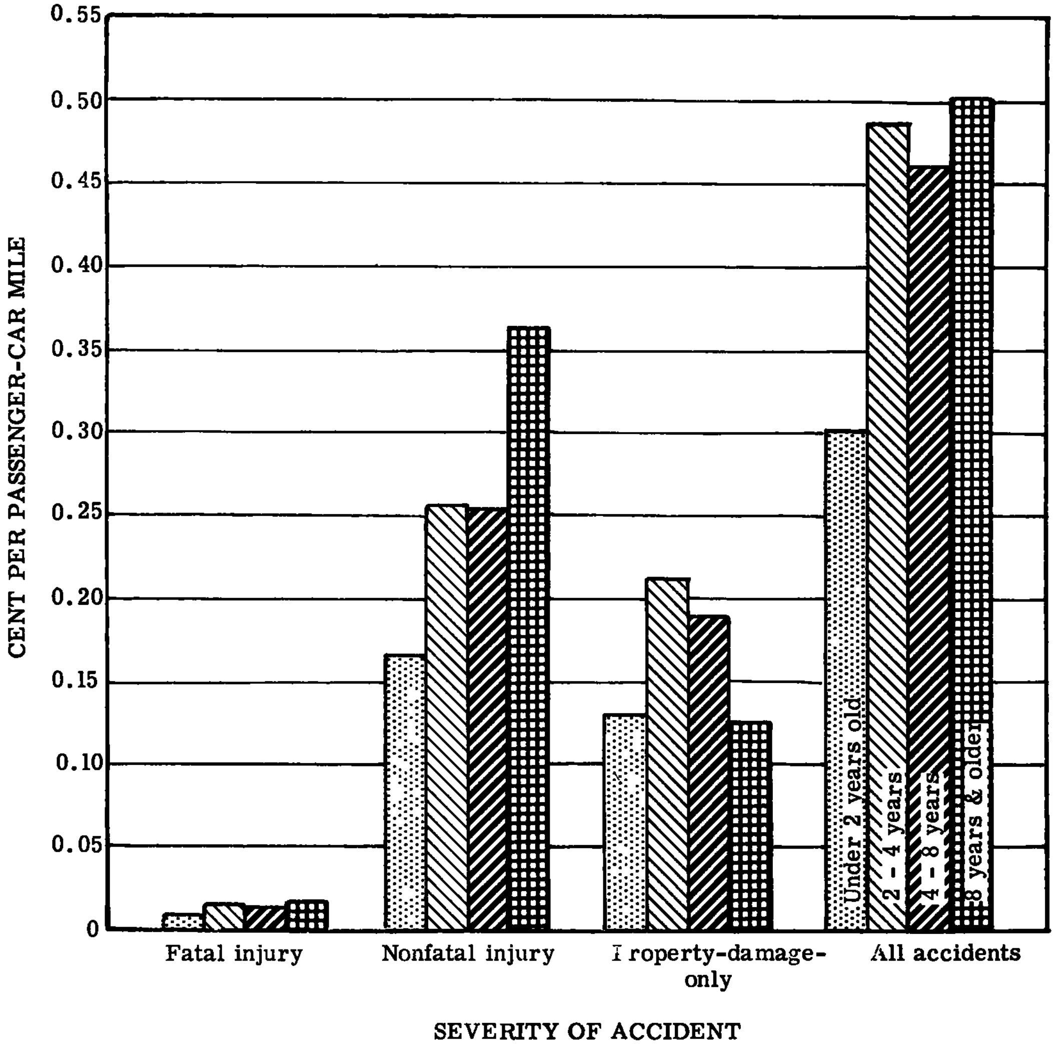

Figure 5. Comparison of cost per mile for passenger cars by severity of accident and age of car.

TABLE 4

TOTAL DIRECT COST OF MOTOR-VEHICLE TRAFFIC ACCIDENTS INVOLVING PASSENGER CARS AND THE ACCIDENT COST PER MILLION PASSENGER CAR-MILES, CLASSIFIED BY AGE OF CAR AND SEVERITY OF ACCIDENT

Age of Passenger Car (yr)	Cost of								Cost per Million Passenger Car-Miles of Travel of:			
	Fatal-Injury Accidents		Non-Fatal-Injury Accidents		Property-Damage-Only Accidents		All Accidents		Fatal-Injury Accidents ($)	Non-Fatal-Injury Accidents ($)	Property Damage-Only Accidents ($)	All Accidents ($)
	Amount ($)	Percent of Total	Amount ($)	Percent of Total	Amount ($)	Percent of Total	Amount ($)	Percent of Total				
Under 2	343,730	20.9	5,572,710	19.4	4,388,040	22.0	10,304,480	20.5	103	1,673	1,317	3,093
2 - 4	507,170	30.9	8,695,640	30.3	7,264,870	36.5	16,467,680	32.8	150	2,565	2,143	4,858
4 - 8	462,820	28.2	8,015,350	28.0	6,001,250	30.2	14,479,420	28.8	147	2,550	1,910	4,607
8 and older	328,030	20.0	6,403,750	22 3	2,240,140	11.3	8,971,920	17.9	186	3,631	1,270	5,087
Total	1,641,750	100.0	28,687,450	100.0	19,894,300	100.0	50,223,500	100.0	141	2,467	1,711	4,319

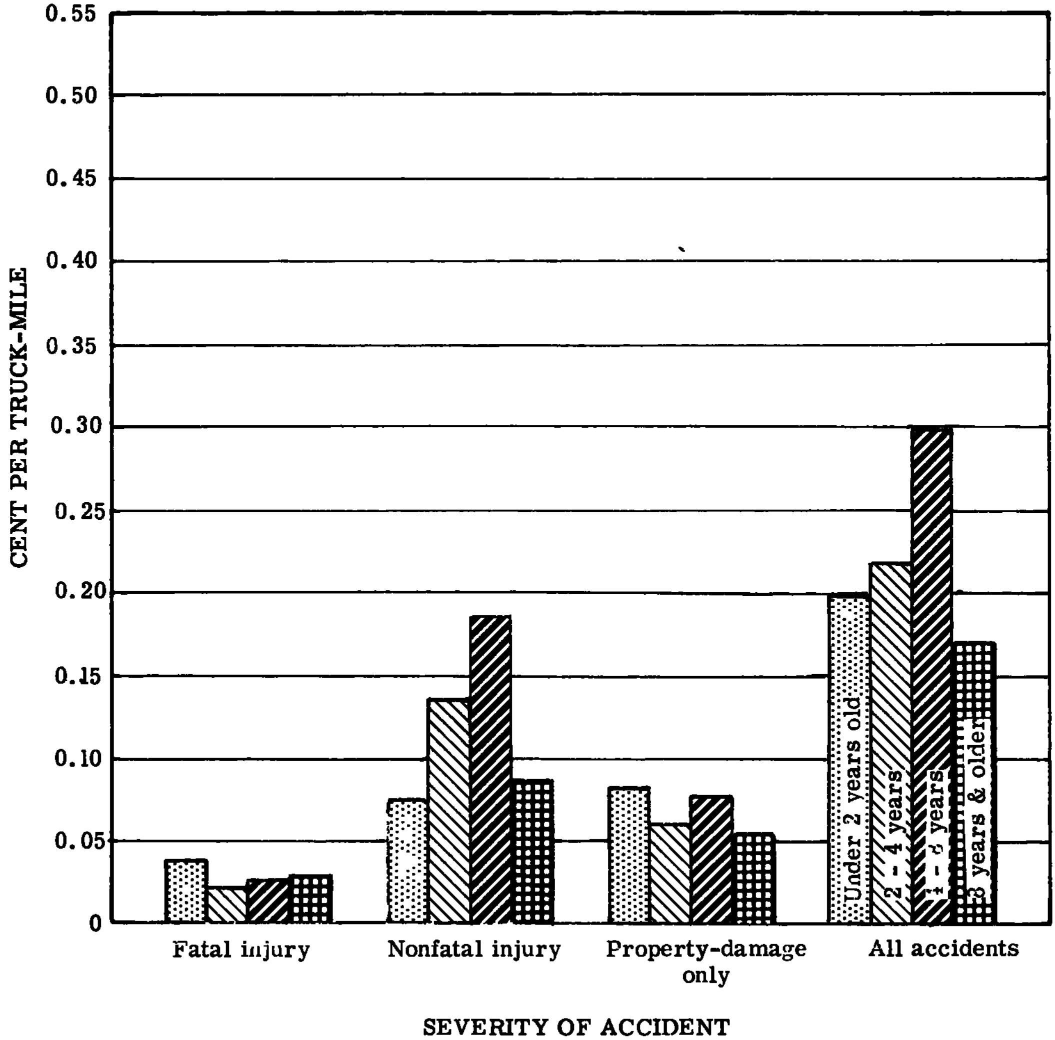

Figure 6. Comparisons of cost per mile for trucks by severity of accident and age of truck.

TABLE 5

TOTAL DIRECT COST OF MOTOR-VEHICLE TRAFFIC ACCIDENTS INVOLVING TRUCKS AND THE ACCIDENT COST PER MILLION TRUCK-MILES, CLASSIFIED BY AGE OF TRUCK AND SEVERITY OF ACCIDENT

Age of Truck (yr)	Cost of:								Cost per Million Truck-Miles of Travel of:			
	Fatal-Injury Accidents		Non-Fatal-Injury Accidents		Property-Damage-Only Accidents		All Accidents		Fatal-Injury Accidents ($)	Non-Fatal-Injury Accidents ($)	Property-Damage-Only Accidents ($)	All Accidents ($)
	Amount ($)	Percent of Total	Amount ($)	Percent of Total	Amount ($)	Percent of Total	Amount ($)	Percent of Total				
Under 2	136,700	24.5	266,300	9.6	290,560	20.1	693,560	14.5	385	751	819	1,955
2 - 4	81,820	14.6	541,170	19.6	273,330	18.9	896,320	18.8	207	1,368	691	2,265
4 - 8	206,370	36.9	1,526,680	55.1	612,510	42.4	2,345,560	49.1	260	1,920	771	2,951
8 and older	133,950	24.0	435,020	15.7	269,180	18.6	838,150	17.6	271	879	544	1,694
Total	558,840	100.0	2,769,170	100.0	1,445,580	100.0	4,773,590	100.0	274	1,357	709	2,340

same scale vividly demonstrates the greater cost per mile of passenger car accidents.

Although not as pronounced as for involvement rates the cost per mile for passenger cars tends to increase with age for all accidents, for the fatal-injury, and for the non-fatal-injury. The cost per mile for property-damage-only accidents drops off for the older vehicles for both passenger cars and trucks. This undoubtedly reflects the reduced value of the older vehicles involved. Also the cost rate for the oldest group of trucks drops off sharply for the non-fatal-injury class.

The fact that the total direct cost of non-fatal-injury accidents was almost 60 percent of the total cost of all accidents for both passenger cars and trucks, of course influences greatly the pattern of cost per mile for all the accidents.

TYPE OF TRUCK

It was not practical to classify passenger cars by different body types. However, trucks were classified into 5 groups: 2-axle, 4-tire panel and pickup trucks; all other 2-axle, 4-tire trucks; 2-axle, 6-tire trucks; 3-axle trucks; and truck-tractor semi-trailer combinations. The truck-tractor semitrailer combinations ranged from 3- to 5-axle units. Because there appeared to be no significant difference in the accident experience of these combination units due to axle arrangement they were treated as a single classification. Truck and full trailer combinations are illegal in Massachusetts and therefore were not represented in the sample.

Table 6 gives the number and travel characteristics of the types of trucks under consideration. During 1955 there were 179,610 trucks registered in Massachusetts. The largest single class of trucks in the Commonwealth was 2-axle, 4-tire panel and pickup trucks, of which there were 77,180 or 43.0 percent of the total truck population. These

TABLE 6

NUMBER OF TRUCKS REGISTERED IN MASSACHUSETTS DURING 1955 AND THEIR TRAVEL CLASSIFIED BY TYPE OF TRUCK

Truck Type	Number of Trucks	Percent of Total	Vehicle Travel: Total Mileage (thousands)	Vehicle Travel: Percent of Total	Vehicle Travel: Average Annual Mileage
Single unit trucks:					
Panels and pickups	77,180	43.0	758,139	37.2	9,823
Other 2-axle, 4-tire	18,350	10.2	165,866	8.1	9,039
2-axle, 6-tire	70,670	39.3	727,412	35.6	10,293
3-axle	3,220	1.8	52,206	2.6	16,213
Truck-tractor, semitrailer	10,190	5.7	336,473	16.5	33,020
Total	179,610	100.0	2,040,096	100.0	11,358

panels and pickups were driven 758,139,000 mi or 37.2 percent of the total-truck-miles of travel. Of almost equal magnitude were the 2-axle, 6-tire single unit trucks. Together these two constitute 82.3 percent of the total number and 72.8 of the vehicle travel. The combination units, although only 5.7 percent of the number of trucks, travel 16.5 percent of the truck-miles.

The usual summary data for the total number and direct costs of accidents by truck type are contained in Tables 7 and 8, respectively. Involvement rates are shown in Figures 7 and 8 and costs per mile in Figure 9. The rate for fatal-injury accidents is again treated separately in Figure 8.

The second classification of trucks, all other 2-axle, 4-tire trucks, have a disproportionate share of the involvements and costs compared to the vehicles registered

TABLE 7

NUMBER OF TRUCKS INVOLVED IN MOTOR-VEHICLE TRAFFIC ACCIDENTS AND THE RATE PER 100 MILLION TRUCK-MILES, CLASSIFIED BY TRUCK TYPE AND SEVERITY OF ACCIDENT

Truck Type	Trucks Involved in								Number of Trucks per 100 Million Truck-Miles of Travel Involved in.			
	Fatal-Injury Accidents		Non-Fatal-Injury Accidents		Property-Damage-Only Accidents		All Accidents		Fatal-Injury Accidents	Non-Fatal-Injury Accidents	Property-Damage-Only Accidents	All Accidents
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total				
Single unit trucks:												
Panels and pickups	19	23.2	1,982	43.9	8,946	36.9	10,947	38.0	2.5	261	1,180	1,444
Other 2-axle, 4-tire	14	17.1	395	8.8	3,097	12.8	3,506	12.2	8.4	238	1,867	2,114
2-axle, 6-tire	30	36.6	1,683	37.3	8,691	35.9	10,404	36.1	4.1	231	1,195	1,430
3-axle	1	1.2	45	1.0	472	2 0	518	1.8	1.9	86	904	992
Truck-tractor-semi-trailer	18	21.9	404	9.0	2,999	12.4	3,421	11.9	5.3	120	891	1,017
Total	82	100.0	4,509	100.0	24,205	100.0	28,796	100.0	4.0	221	1,186	1,412

TABLE 8

TOTAL DIRECT COST OF MOTOR-VEHICLE TRAFFIC ACCIDENTS INVOLVING TRUCKS AND THE ACCIDENT COST PER MILLION TRUCK-MILES CLASSIFIED BY TRUCK TYPE AND SEVERITY OF ACCIDENT

Truck Type	Cost of:								Cost per Million Truck-Miles of Travel of.			
	Fatal-Injury Accidents		Non-Fatal-Injury Accidents		Property-Damage-Only Accidents		All Accidents		Fatal-Injury Accidents ($)	Non-Fatal-Injury Accidents ($)	Property-Damage-Only Accidents ($)	All Accidents ($)
	Amount ($)	Percent of Total	Amount ($)	Percent of Total	Amount ($)	Percent of Total	Amount ($)	Percent of Total				
Single unit trucks.												
Panels and pickups	114,510	20.5	1,050,880	37 9	767,860	53.1	1,933,250	40.5	151	1,386	1,013	2,550
Other 2-axle, 4-tire	88,320	15.8	315,710	11.4	107,340	7.4	511,370	10.7	532	1,903	647	3,083
2-axle, 6-tire	210,260	37.6	1,256,550	45.4	414,470	28.7	1,881,280	39.4	289	1,727	570	2,586
3-axle	-	-	13,410	0.5	6,360	0.5	19,770	0.4	-	257	122	379
Truck-tractor-semi-trailer	145,750	26.1	132,620	4.8	149,550	10.3	427,920	9.0	433	394	444	1,272
Total	558,840	100.0	2,769,170	100.0	1,445,580	100.0	4,773,590	100.0	274	1,357	709	2,340

and miles traveled by this class. They generally have the highest involvement and cost rates of any type of truck. There were 18,350 vehicles of this type registered in Massachusetts during 1955. This 10.2 percent of the total registered trucks accounted for 8.1 percent of the total truck mileage, 12.2 percent of the involvements, and 10.7 percent of the direct costs.

The involvement rate per 100 million miles of travel for this class of truck was 8.4 for fatal, 238 for non-fatal-injury, and 1,867 for property-damage-only accidents. The involvement rate for all accidents was 2,114, which was 50 percent greater than the average rate of 1,412 for trucks of all types. The fatal-injury involvement rate was more than 3 times that of 2-axle panels and pickups.

From Figure 9 the accident cost per mile for all other 2-axle, 4-tire trucks was 0.053 cent for fatal injury, 0.190 cent, for non-fatal-injury, and 0.065 cent for property-damage-only accidents or a total cost of 0.308 cent per mile. The rate for the fatal-injury class is more than 3 times that for panels and pickups and twice the average cost rate of 0.027 cent for fatal-injury accidents for all trucks. The non-fatal-injury rate is 40 percent greater than the average non-fatal-injury cost rate of 0.136 for all trucks. Only for property-damage-only involvements was the cost rate less than the average for all trucks. The total cost rate for this truck type was 32 percent greater than the average cost rate of 0.234 cent for all trucks. The average cost rates for all trucks are given in the totals in Table 8.

In the order of appearance in Figures 7, 8, and 9 the first type (panels and pickups) and the third type (2-axle, 6-tire) appear generally to have about the same involvement rate and cost per mile. For all accidents the involvement rates (Fig. 7) were 1,444 and 1,430, respectively. From Figure 9 the cost in cents per mile was 0.255 for panels and pickups and 0.259 for 2-axle, 6-tire trucks; these two groups of vehicles which constituted 82.3 percent of the total registration accounted for 79.9 percent of the total direct cost of truck accidents.

Considering the fatal-injury class of accidents shown in Figure 8, the involvement rate for the panel and pickups was 2.5 which was considerably less than the average rate of 4.0 for all trucks. The same rate for the 2-axle trucks (6-tire) was 4.1 and is the third highest of the five vehicle types.

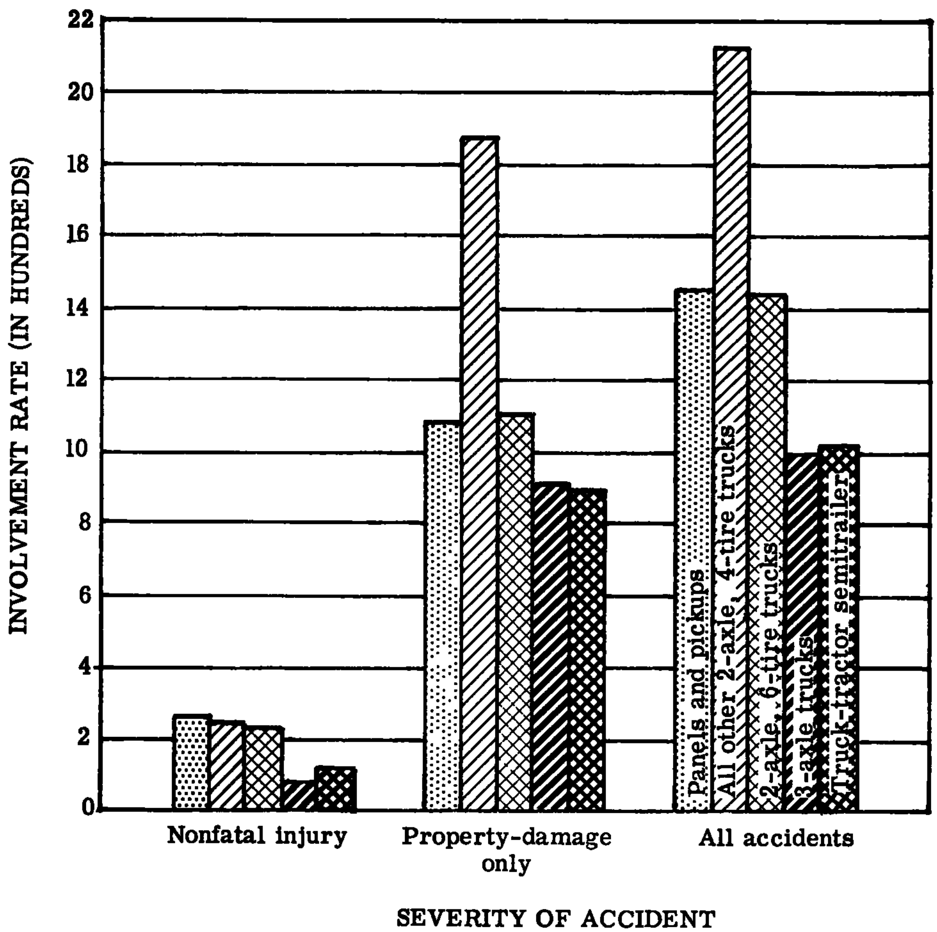

Figure 7. Comparison of non-fatal injury, property-damage-only, and all accident involvement rates per 100 million truck-miles of travel by type of truck.

The fourth class of trucks, 3-axle trucks, constituted only 1.8 percent or 3,220 of all trucks registered in Massachusetts during 1955, and accounted for exactly the same percentage of the total number of accidents. The total cost of accidents for this group was only 0.4 percent of the total cost of accidents for all trucks.

The number of 3-axle trucks involved in accidents per 100 million miles of travel by this group was 992. Classified by severity, this involvement rate was 1.9 of these trucks in fatal-injury accidents, 86 in non-fatal-injury accidents, and 904 in accidents resulting in property-damage-only. These were, in general, the lowest rates for any of the five truck classifications under consideration. Similarly, the cost in cents per mile (Fig. 9) was the lowest by far for any of the five types of trucks in all severity classes. These cent-per-mile rates were 0.026 for non-fatal-injury, 0.012 for property-damage-only, and 0.038 for all accidents. There were no costs connected with the single reported involvement in a fatal accident.

The data for the fifth and final type of truck, the truck-tractor semitrailers, offered a study of contrasts. Although only 5.7 percent of the trucks registered, these vehicles were responsible for 11.9 percent of all trucks involved in traffic accidents, and 9.0 percent of the total direct cost of all truck accidents. On the other hand, the rates of involvement and cost per mile for all except the fatal-injury accidents were below the average values for all trucks.

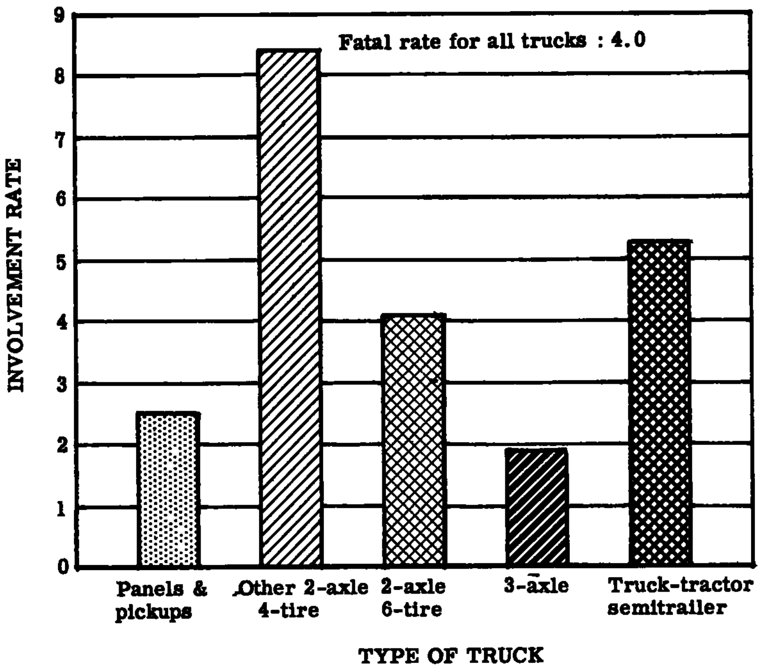

Figure 8. Comparison of truck involvement rate per 100 million truck-miles of travel in fatal accidents.

A study of the total cost of accidents for truck-tractor semitrailers by severity class indicates that fatal-injury accidents account for 34.1 percent, non-fatal-injury accidents for 31.0 percent, and property-damage-only accidents for 34.9 percent of the total costs incurred. In contrast, considering the total direct cost for all truck accidents, fatal-injury accidents account for only 11.7 percent of the total cost, where non-fatal-injury accidents and property-damage-only accidents account for 58.0 percent and 30.3 percent, respectively.

In this connection, it is of interest to note that the combined cost of fatal and non-fatal-injury accidents of truck-tractor semitrailers was 65.1 percent of the total cost of accidents for this class of vehicle, whereas for all single-unit trucks the combined fatal and non-fatal-injury cost was 70.2 percent of the cost of all single-unit truck accidents. The difference results from the different proportion of fatal and non-fatal-injury accidents and cost experience of such accidents for these classes of trucks.

This disproportionate cost of the fatal-injury accidents of truck-tractor semitrailers is accentuated by the fact that the average cost of a fatal-injury accident for this group was $8,100 as compared to an average cost of $6,450 for a fatal-injury accident of a single-unit truck. In addition to higher cost for fatal-injury accidents, one out of every 190 truck-tractor, semitrailer involvements was fatal whereas only 1 in every 409 involvements for single-unit trucks was fatal.

When viewed with consideration given to exposure in truck-miles of travel, these higher percentages of truck-tractor semitrailer involvements and costs are somewhat modified. The involvement rate for all accidents was 1,017 per 100 million miles of travel for truck-tractor, semitrailer combinations. Classified by severity this rate was 5.3 fatal-injury, 120 non-fatal-injury, and 891 property-damage-only involvements per 100 million miles of travel. The cost of all accidents per mile of travel was 0.127 cent. By severity class this cost rate was 0.043 cent for fatal-injury, 0.039 cent for non-fatal-injury, and 0.044 cent for property-damage-only accidents. It is evident from Figures 7 and 9 that these vehicles have involvement and cost rates well below

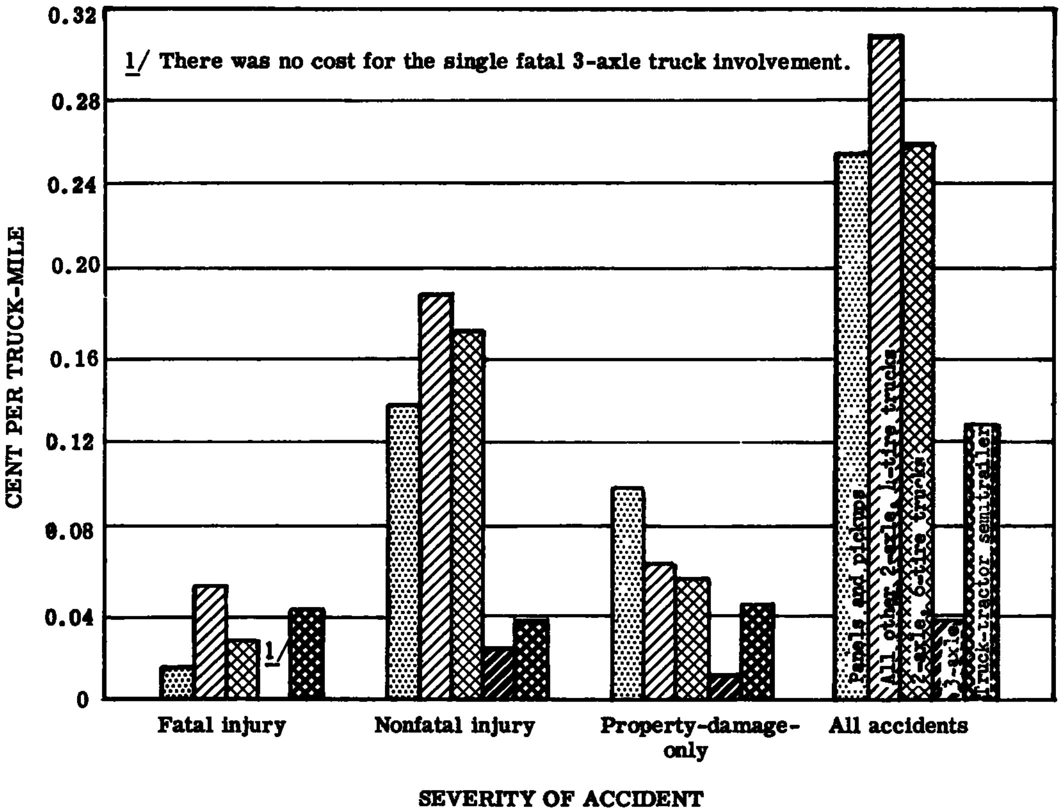

Figure 9. Comparison of the accident cost per mile of travel by type of truck and severity of accident.

those of single unit trucks for non-fatal-injury and property-damage-only accidents. This is also true for the involvement and cost rates for all accidents which were lower than those of any other type except 3-axle trucks.

However, this is not so with regard to the fatal involvement and cost rates, as these rates for the combinations are considerably higher than those of single-unit trucks. The fatal involvement rate per 100 million miles was 5.3 for truck-tractor, semi-trailer combinations, and 3.8 for all single-unit trucks. The cost of fatal accidents per mile of travel was 0.043 cent for the combinations compared to 0.024 cent for all single-unit trucks.

It is apparent from the foregoing discussion that any total view of trucks involved in accidents and their costs is predominately weighted by the number of 2-axle, 4-tire panel and pickup trucks and 2-axle, 6-tire trucks, which comprised 82.3 percent of the vehicles registered, 72.8 percent of the total truck-miles of travel, 74.1 percent of the total number of involvements, and 79.9 percent of the total direct costs. Thus, these two classes of trucks dominate the total involvement and total cost rates on any basis. The combinations play a rather important part in the total cost in relation to the number registered, but the large average annual mileage of this group tends to offset their disproportionate costs when viewed on an exposure basis.

REGISTERED GROSS WEIGHT

The analysis to this point has considered the relationship of truck and passenger-car accident costs, and the variation of truck accident costs with age of vehicle and type of vehicle classified by axle arrangement. Another relationship of interest particularly for economic analysis is that which exists between accident cost and registered gross weight.

Of the 179,610 trucks registered in Massachusetts during 1955, 100,940 or 56.2 percent were registered under 8,500 lb gross vehicle weight. The remainder were distributed 36,340 or 20.2 percent between 8,500 and 16,499 lb, 19,050 or 10.6 percent were between 16,500 and 24,499 lb, 9,540 or 5.3 percent were between 24,500 and 36,499 lb, and the 13,740 or 7.7 percent were 36,500 lb and over.

In addition to the registration data, Table 9 gives the vehicle travel for each group

TABLE 9

NUMBER OF TRUCKS REGISTERED IN MASSACHUSETTS DURING 1955 AND THEIR TRAVEL CLASSIFIED BY REGISTERED GROSS VEHICLE WEIGHT

Gross Vehicle Weight (lb)	Number of Trucks	Percent of Total	Vehicle Travel: Total Mileage (thousands)	Vehicle Travel: Percent of Total	Vehicle Travel: Average Annual Mileage
8,499 and under	100,940	56.2	949,636	46.5	9,408
8,500 - 16,499	36,340	20.2	333,960	16.4	9,190
16,500 - 24,499	19,050	10.6	224,139	11.0	11,766
24,500 - 36,499	9,540	5.3	132,603	6.5	13,900
36,500 and over	13,740	7.7	399,758	19.6	29,094
Total	179,610	100.0	2,040,096	100.0	11,358

of registered gross vehicle weight. It is important to notice for future consideration of involvement and cost rates that the annual average mileage increases with registered weight. The increase between the last two weight groups is particularly significant. Trucks in the heaviest weight group traveled more miles in a year than those in any

TABLE 10

NUMBER OF TRUCKS INVOLVED IN MOTOR-VEHICLE TRAFFIC ACCIDENTS AND THE RATE PER 100 MILLION TRUCK-MILES, CLASSIFIED BY REGISTERED GROSS VEHICLE WEIGHT AND SEVERITY OF ACCIDENT

Gross Vehicle Weight (lb)	Trucks Involved in: Fatal-Injury Accidents		Non-Fatal-Injury Accidents		Property-Damage-Only Accidents		All Accidents		Number of Trucks per 100 Million Truck-Miles of Travel Involved in			
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Fatal-Injury Accidents	Non-Fatal-Injury Accidents	Property-Damage-Only Accidents	All Accidents
8,499 and under	41	50.0	2,662	59.1	11,001	45.5	13,704	47.6	4.3	280	1,158	1,443
8,500 - 16,499	13	15.8	722	16.0	4,998	20.6	5,733	19.9	3.9	216	1,497	1,717
16,500 - 24,499	7	8 5	416	9.2	3,289	13.6	3,712	12.9	3.1	186	1,467	1,656
24,500 - 36,499	4	4.9	245	5.4	2,084	8.6	2,333	8.1	3.0	185	1,572	1,759
36,500 and over	13	15.9	387	8.6	2,562	10.6	2,962	10.3	3 3	97	641	741
Unknown	4	4.9	77	1.7	271	1.1	352	1.2	-	-	-	-
Total	82	100.0	4,509	100.0	24,205	100.0	28,796	100.0	4.0	221	1,186	1,412

TABLE 11

TOTAL DIRECT COST OF MOTOR-VEHICLE TRAFFIC ACCIDENTS INVOLVING TRUCKS AND THE ACCIDENT COST PER MILLION TRUCK-MILES, CLASSIFIED BY REGISTERED GROSS VEHICLE WEIGHT AND SEVERITY OF ACCIDENT

Gross Vehicle Weight (lb)	Cost of: Fatal-Injury Accidents		Non-Fatal-Injury Accidents		Property-Damage-Only Accidents		All Accidents		Cost per Million Truck-Miles of Travel of:			
	Amount ($)	Percent of Total	Amount ($)	Percent of Total	Amount ($)	Percent of Total	Amount ($)	Percent of Total	Fatal-Injury Accidents ($)	Non-Fatal-Injury Accidents ($)	Property-Damage-Only Accidents ($)	All Accidents ($)
8,499 and under	268,040	48.0	1,915,460	69.1	872,060	60.3	3,055,560	64.0	282	2,017	918	3,218
8,500 - 16,499	130,990	23.4	378,530	13.7	242,910	16.8	752,430	15 8	392	1,133	727	2,253
16,500 - 24,499	19,990	3.6	209,950	7.6	126,920	8 8	356,860	7.5	89	937	566	1,592
24,500 - 36,499	46,900	8.4	71,600	2.6	73,110	5.0	191,610	4.0	354	540	551	1,445
36,500 and over	78,310	14.0	143,270	5.2	122,160	8.5	343,740	7.2	196	358	306	860
Unknown	14,610	2.6	50,360	1.8	8,420	0.6	73,390	1.5	-	-	-	-
Total	558,840	100.0	2,769,170	100.0	1,445,580	100.0	4,773,590	100.0	274	1,357	709	2,340

other group except those registered under 8,500 lb. Light trucks have often been compared to passenger cars because of many similar vehicle characteristics. One of these similarities is average annual travel per vehicle. The average annual travel of passenger cars and that of light trucks are approximately equal. Passenger cars averaged 9,380 mi of travel annually and light trucks averaged 9,408 mi of travel annually. By comparing the involvement rate of 1,910 per 100 million vehicle-miles of passenger cars with the involvement rate of 1,443 for light trucks it may be seen that passenger cars are involved in 32 percent more accidents on a mileage basis.

Table 10 gives the total number of trucks involved in accidents and the involvement rate in number per 100 million miles of travel for each gross weight group by severity of accident. When the proportion of heavy trucks involved in accidents is compared with the proportion of heavy trucks in the total truck registration, the comparison presents a somewhat unfavorable picture for heavy trucks. For example, in the 36,500 lb and over group, the percentage registered was 7.7, and the percentage involved in accidents was 10.3. Data on the costs of accidents, arranged in a similar manner in Table 11, show that the reverse is true. Here the percentage of the total accident cost was 7.2 for the heaviest weight group.

The involvement rates for fatal-injury accidents are shown separately from the other severity class in Figure 10, and appear to decrease with registered weight over the range covered by the first three groups and then tend to level off. In Table 10 it was seen that the proportion of the total vehicles in the heaviest group involved in fatal-injury accident was high in comparison to the proportion of vehicles in the other groups so involved. This group had one vehicle in fatal accident for every 30 vehicles in non-fatal accident where the average rate for the other trucks was 1 in 62. On an exposure basis, the vehicles registered in the heaviest group have a favorable involvement rate. It was 3.3 per 100 million miles of travel as compared to a rate of 4.0 for the remainder of the trucks.

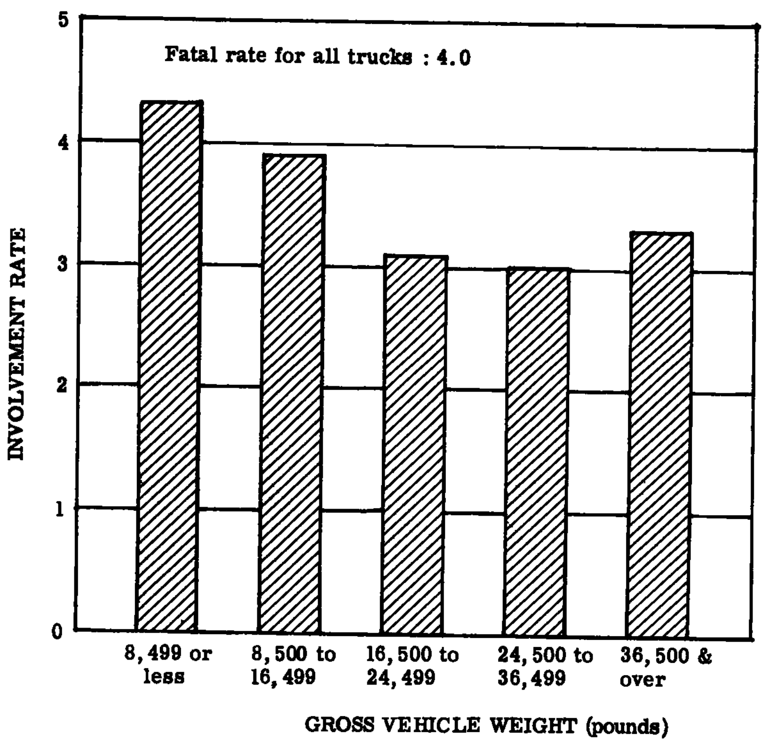

Figure 10. Comparison of truck involvement rate per 100 million truck-miles of travel in fatal accidents by gross vehicle weight.

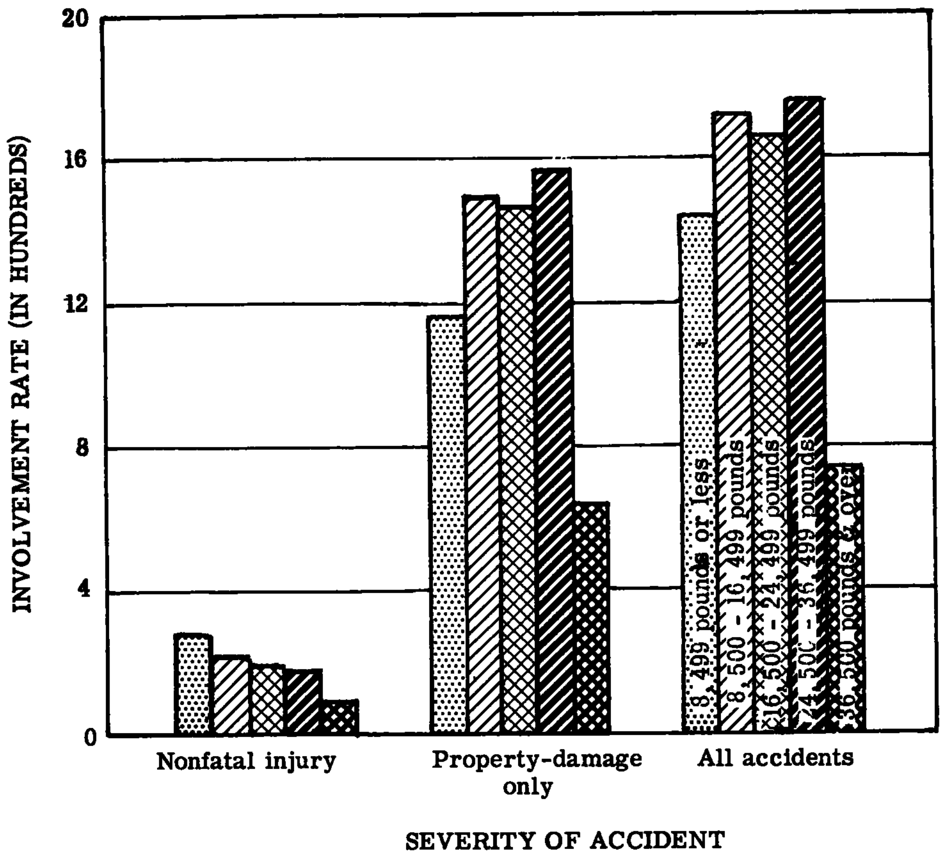

Figure 11. Comparison of non-fatal injury, property-damage-only and all accident involvement rates per 100 million truck-miles of travel by gross vehicle weight.

The involvement rates for the other two severity classes and for all the accidents are shown in Figure 11. In the case of non-fatal-injury accidents, the rates decrease with registered weight. However, for the property-damage-only accidents the tendency is for an increase with weight excepting the last group of heavier vehicles for which the rate drops off sharply to less than one-half that for the other groups. The property-damage only involvement rate was 641 for heavy trucks and 1,303 for all other trucks. The rate for all accidents, regardless of severity, is 741 for heavy trucks and is 1,554 for all other trucks, which is clearly twice as bad as the record of the heaviest trucks on the basis of exposure.

A look at accident cost rates per mile of travel (Fig. 12) will show similar favorable rates for the heaviest trucks in contrast to the cost rates for the trucks in the other weight groups. For non-fatal-injury accidents the cost rate of 0.036 cent per mile for heavy trucks was about one-fourth of the cost rate of 0.157 for all other trucks in accidents of comparable severity. The property damage-only cost rate was 0.031 cent per mile for heavy trucks and 0.080 for all other trucks. The cost rate for all accidents was 0.086 cent per mile for heavy trucks, which was about one-third of the cost rate of 0.266 for all other trucks.

A most significant result of the report is the very definite decrease of accident cost per mile of travel with increase of registered gross vehicle weight. This is the first time such data has become available. With reference to the results for all accidents in Figure 12, the cost rate ranges from 0.322 cent per mile for the lightest group to 0.086 cent per mile for the heaviest group.

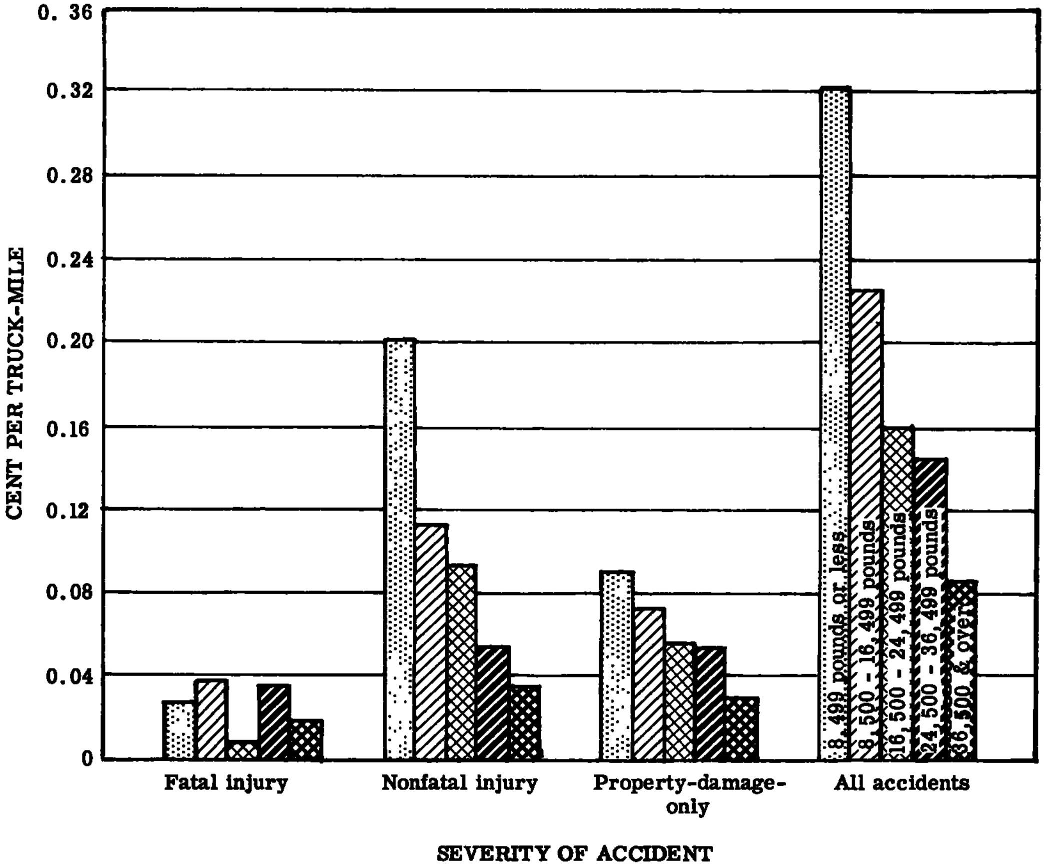

Figure 12. Comparison of the accident cost per mile of travel by gross vehicle weight and severity of accident.

SUMMARY OF FINDINGS

It should be clearly understood in considering the reported results that they are based only on data for Massachusetts. Whether or not the same patterns and trends will hold for other states will be determined by studies now under way and planned for the future.

1. The cost of accidents per mile of travel for passenger cars is nearly double that of trucks, with the exception of cost per mile for fatal accidents.
2. Both the involvement rate and accident cost per mile for passenger cars increases with the age of the car. The same is not true of trucks.
3. Panels and pickups, together with 2-axle, 6-tire trucks, constitute 5 out of every 6 trucks registered and thus dominate the involvement and accident cost picture.
4. Truck-tractor semitrailers had the best accident record when viewed from exposure with the sole exception of a high fatal involvement rate and fatal cost per mile.
5. The most important of all the relationships discovered with regard to registered gross weight from the standpoint of economic analysis of accidents was the decrease of accident cost per mile as the gross weight increased.
6. The involvement rate and cost per mile of the heaviest group of trucks were favorable when compared to those of all other trucks. This may well be the most significant finding of this report.

Economic Cost of Traffic Accidents in Relation to the Human Element

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Extensive use of traffic accident cost data developed by the Massachusetts Department of Public Works and by the Massachusetts Registry of Motor Vehicles in cooperation with the U. S. Bureau of Public Roads was made in the Congressional report, "The Federal Role in Highway Safety." (House Document No. 93, 86th Congress, 1st Session, 1959.) These data have also been used as the basis of other reports relating economic costs to accident types, characteristics of the street and highway systems, and to the characteristics of motor vehicles. This article, using data from the same source, relates the economic cost of motor-vehicle traffic accidents to persons.

Comparisons involving passenger cars of Massachusetts registry in 1953 are made of the accident experience of automobile drivers, passengers, pedestrians, and other persons involved in motor-vehicle traffic accidents. The number of accidents, the number of persons involved, the number of persons injured fatally, seriously, and superficially, the number hospitalized, and the number permanently and temporarily disabled are discussed. Equally important, the cost of accidents and injuries is revealed.

Injury rates and injury cost rates, number of persons injured per 100,000 population, and the per capita cost of their injuries show the relative economic importance of the accidents and injuries experienced by each class of persons.

The Massachusetts study of the economic cost of motor-vehicle accidents encompassed the total driving experience of all licensed operators of passenger cars and cargo-carrying vehicles of Massachusetts registry including those who experienced accidents and those who did not, in the operation of passenger cars during 1953, within or outside the state, and in the operation of cargo-carrying vehicles during 1955. However, the discussion in this paper is confined to the accident experience of Massachusetts licensed passenger-car operators and persons in motor-vehicle traffic accidents involving passenger cars on public streets and highways of the state. This paper excludes accident experience of truck operators, the number and cost of accidents occurring on private property, and the number and cost of mishaps involving acts of vandalism and acts of God.

● STATISTICAL STUDIES of the motor-vehicle accident costs were based on the probability sample designed to be accurate within 10 percent. To determine the number of persons involved in fatal accidents, original accident reports were reviewed and the number of persons reported represents a firm figure. The number of drivers involved in non-fatal-injury and property-damage-only accidents was unavoidably slightly inflated because a driver who was involved in more than one accident during the year was counted as one driver each time he was involved in an accident. The number of passengers involved in accidents was estimated on the basis of an average passenger-car occupancy of 1.6 persons. The number of pedestrians and "other" persons non-fatally injured, however, was obtained from the original accident reports.

Costs reflected in this article are direct costs and consist exclusively of the money value of damage to property, injuries to persons, worktime lost, loss of use of vehicle, legal and court costs, damage awards in excess of actual cost, and small miscellaneous items. The number of persons losing worktime includes only those employed in gainful occupations. The number of workdays lost includes time lost for treatment of injuries, for convalescence, and for settlement of claims.

The activity class, "others," used throughout this article, consists of persons using conveyances other than motor-vehicles—such as bicycles, horsedrawn vehicles, and trolley cars.

Physical injury that impaired earning capacity is referred to as disability. The degree of disability as used is a measure of the extent to which persons injured in motor-vehicle traffic accidents were handicapped in making a living. There are two classes of disability—temporary disability and permanent disability. Under the temporary disability class, there are two degrees of disability—total and partial. The degree of permanent disability is expressed in percentages of 25, 50, 75, and 100.

The data regarding persons permanently and temporarily disabled as a result of motor-vehicle traffic accidents in Massachusetts appeared to be incomplete and therefore not usable in this analysis. However, rather than include no information on this important part of the problem, an approximation was derived by applying to the number of persons injured in Massachusetts, the percentage of persons injured that were disabled in the State of Utah, where a similar study was being conducted.

PERSONS IN ACCIDENTS

In 1953, the population of Massachusetts was 4,773,000. Of this total, 362,280 persons were involved in 131,536 motor-vehicle traffic accidents. Table 1 gives the number of accidents and their severity, the number of persons in accidents, the severity of their injuries, and their activity at the time of the accident.

TABLE 1

NUMBER OF PERSONS IN TRAFFIC ACCIDENTS INVOLVING PASSENGER CARS, CLASSIFIED BY SEVERITY OF ACCIDENT AND ACTIVITY

	Severity of Accident							
	Fatal		Non-Fatal Injury		Property-Damage Only		All Accidents	
Item of Comparison	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Involvements:								
Severity of injuries:								
Persons fatally injured	421	58.6					421	0.1
Persons non-fatally injured	168	23.4	44,883	47.9			45,051	12.4
Persons not injured	129	18.0	48,751	52.1	267,928	100.0	316,808	87.5
Total persons involved	718	100.0	93,634	100.0	267,928	100.0	362,280	100.0
Activity of persons:								
Drivers	344	47.9	54,260	57.9	167,455	62.5	222,059	61.3
Passengers	206	28.7	32,556	34.8	100,473	37.5	133,235	36.8
Pedestrians	158	22.0	5,735	6.1			5,893	1.6
Others	10	1.4	1,083	1.2			1,093	0.3
Total persons involved	718	100.0	93,634	100.0	267,928	100.0	362,280	100.0
Accidents:								
Number of accidents	315		33,270		97,951		131,536	
Persons per accident	2.3		2.8		2.7		2.7	
Persons injured per accident	1.9		1.3				0.3	

The most significant point drawn from Table 1 was the great number of persons involved and the relatively small number of persons killed and injured in motor-vehicle traffic accidents. The 362,280 persons involved in motor-vehicle traffic accidents during 1953 represented one out of every 13 persons, or 7.6 percent of the total population. However, of all the persons involved in motor-vehicle traffic accidents only 45,472, or 12.5 percent, were either fatally or non-fatally injured. The vast majority of persons involved, 316,808 (87.5 percent), experienced no injury whatever.

In the distribution of persons involved in motor-vehicle traffic accidents by their activity at the time of accident, there were more drivers involved in accidents than there were persons in the other three activity classes combined. Of the total persons involved in accidents 61.3 percent were drivers, 36.8 percent were passengers, 1.6 percent were pedestrians, and 0.3 percent were others.

An interesting distribution (Fig. 1) is the makeup of accidents of different severity. All persons in fatal-injury accidents were not killed and all persons in non-fatal-injury accidents were not injured. (For example, two cars, each with two occupants, may have collided. One occupant may have been fatally injured, another non-fatally injured, and the other two occupants may have avoided injury entirely.) Of the 718 persons involved in fatal-injury accidents, 59 percent were killed, 23 percent were non-fatally injured, and 18 percent sustained no injuries whatever. Of the 93,634 persons involved in non-fatal-injury accidents, 48 percent were injured and 52 percent were not injured.

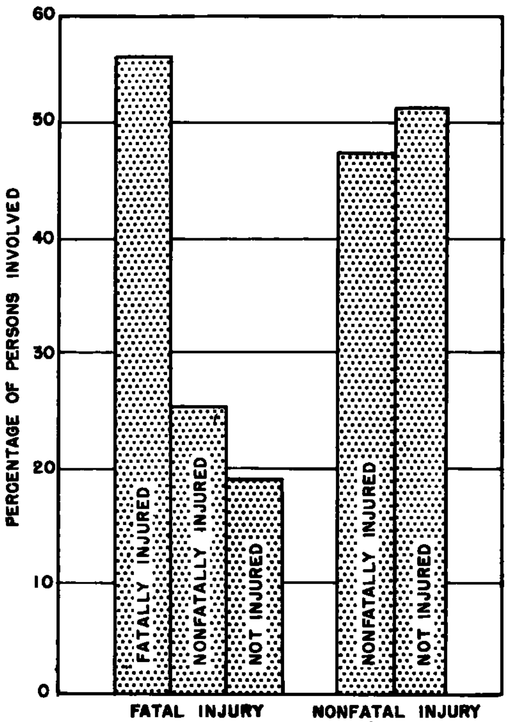

Figure 1. Percentage distribution of persons involved in accidents, classified by severity of injury.

In terms of number of accidents rather than involvement of persons, it may be noted from Table 1 that of the 131,536 accidents reported 75 percent were property-damage-only accidents, and only 0.2 percent were fatal-injury accidents.

PERSONS INJURED AND INJURY RATES

In Table 2 it is found that only 1 out of 8 persons involved in motor-vehicle accidents was injured and that more than one-half of those injured were not seriously injured. In terms of numbers, there were 421 persons fatally injured and 45,051 persons non-fatally injured. Of the persons non-fatally injured 27,006 experienced only superficial injuries such as mild shock, bumbs, scratches, and bruises. The remaining 18,045 experienced serious injuries such as concussions, fractured bones, internal injuries, deep cuts, and dismemberment of body extremities.

Data from Table 2 indicate that more than 1 out of every 3 persons killed in traffic accidents was a pedestrian. It is significant, too, that more passengers than drivers were killed in traffic accidents, since on the basis of average car occupancy of 1.6 persons, the relative exposure of drivers as compared to that of passengers was in a ratio of 5 to 3. As to the number of persons non-fatally injured in traffic accidents, drivers constituted approximately one-half of the total.

In Figure 2, the fatal injury rate—persons fatally injured in traffic accidents per 100,000 population—relates the high incidence of pedestrians and passengers in fatal

TABLE 2

NUMBER OF PERSONS IN TRAFFIC ACCIDENTS AND NUMBER PER 100,000 POPULATION, CLASSIFIED BY SEVERITY AND ACTIVITY

Activity of Persons	Persons Injured					Total Not Injured	Total Involved in Accidents
	Fatally	Non-Fatally			Total Injured		
		Seriously	Superficially	Total			
Involvements:							
Drivers	102	12,800	9,434	22,234	22,336	199,723	222,059
Passengers	151	4,275	12,914	17,189	17,340	115,895	133,235
Pedestrians	158	770	3,775	4,545	4,703	1,190	5,893
Others	10	200	883	1,083	1,093	-	1,093
Total persons	421	18,045	27,006	45,051	45,472	316,808	362,280
Involvements per 100,000 population:							
Drivers	2.1	268	198	466	468	4,184	4,652
Passengers	3.2	89	271	360	363	2,428	2,791
Pedestrians	3.3	16	79	95	99	25	124
Others	0.2	5	18	23	23	-	23
Total persons	8.8	378	566	944	953	6,637	7,590

accidents. Figure 3 shows the rate at which persons in traffic accidents were seriously and superficially injured and points up the superficial nature of the majority of traffic accident injuries and also shows that a much higher percentage of drivers were seriously injured than any other activity group. Furthermore, it shows that most pedestrians not fatally injured were only superficially injured.

Age and Sex of Persons Injured

Table 3 gives the number of persons and the number per 100,000 population in each age and sex group that were injured in traffic accidents, classified by severity of injury. Of every 100,000 persons in the state, 953 were injured in a traffic accident during the year and the majority of those injured were male persons. A total of 25,579 males were fatally and non-fatally injured, or 1,107 males per 100,000 male persons.

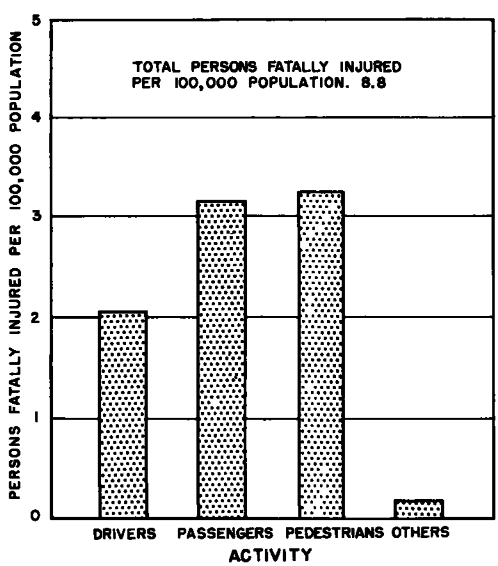

Figure 2. Fatal-injury rate, classified by activity.

Categorized by age groups, more persons from 30 to 39 years of age were injured than in any other age group, and the next largest category was the 20-29 age group. Of all persons injured 43 percent were in these two age groups. However, of more importance from the economic point of view, 70 percent of the persons injured were from 20 to 59 years of age—the ages supplying most of the labor force of the state.

In every age group except one, male persons had a higher fatal-injury rate than females; and in the one exception the rate was the same for both sexes. In the 20-29 age group for males and in the 50 and over age groups for both males and females, a relatively high fatal-injury rate occurred. The higher rates in the older age groups were believed to have been largely brought about by pedestrian deaths.

Turning to the non-fatal injuries per 100,000 in each age and sex group (Table 3), males had a higher rate at every age, with only the youngest age group evidencing a closeness. Males in the 20-29 and 30-39 age groups had the highest injury rate, and females 60 and over had the lowest non-fatal-injury rate.

Persons Hospitalized

Table 4 gives the number of persons non-fatally injured in traffic accidents that were hospitalized. One of the most remarkable items derived from the 1953 Massachusetts accident study was evidence of the relatively small number of non-fatally-injured persons that required hospitalization. Only 15 percent of the persons non-fatally injured spent time in the hospital as a result of their injuries. Table 4 also shows that the 6,647 persons confined to the hospital remained there a total of 62,148 days or an average of 9.4 days per person.

During 1953, of the 45,051 persons non-fatally injured, 16,204, or 35.9 percent were examined in a hospital after the accident. Of those examined, 6,647 were confined while 9,557 persons were released from the hospital immediately after receiving emergency treatment. There were 28,847 persons, or 61.4 percent of all the persons non-fatally injured, that were either treated outside hospitals or received no professional treatment. These figures are additional evidence of the superficial nature of a large majority of traffic accident injuries.

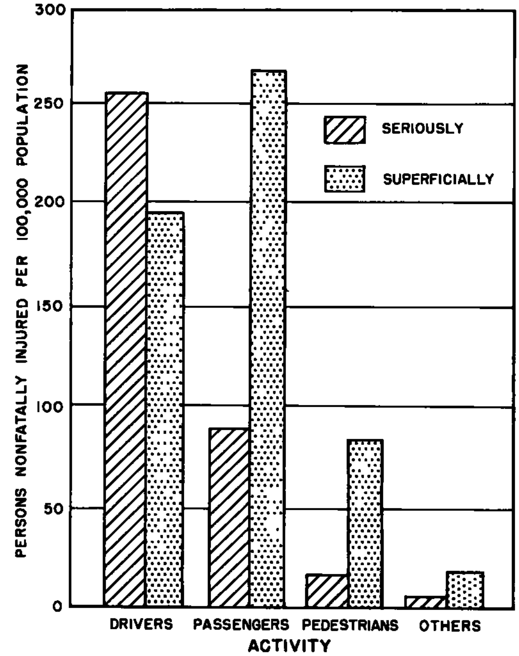

Figure 3. Non-fatal-injury rate, classified by activity and severity.

Only 10 percent of the passengers that were injured required hospitalization, as compared with 16 percent of the drivers and 25 percent of the injured pedestrians. Persons in the "other" category that were hospitalized had the highest percentage rate,

TABLE 3

NUMBER OF PERSONS INJURED IN ACCIDENTS AND NUMBER INJURED PER 100,000 POPULATION, CLASSIFIED BY AGE, SEX, AND SEVERITY

Age of Persons	Males Injured			Females Injured			All Persons Injured		
	Fatally	Non-Fatally	Total	Fatally	Non-Fatally	Total	Fatally	Non-Fatally	Total
Number injured:									
Under 10	25	2,993	3,018	12	2,238	2,250	37	5,231	5,268
10 - 19	26	3,070	3,096	6	1,694	1,700	32	4,764	4,796
20 - 29	59	5,187	5,246	13	4,542	4,555	72	9,729	9,801
30 - 39	25	5,579	5,604	7	4,297	4,304	32	9,876	9,908
40 - 49	22	3,668	3,690	6	2,741	2,747	28	6,409	6,437
50 - 59	36	2,958	2,994	41	2,776	2,817	77	5,734	5,811
60 and over	75	1,856	1,931	68	1,452	1,520	143	3,308	3,451
Total	268	25,311	25,579	153	19,740	19,893	421	45,051	45,472
Number per 100,000:[1]									
Under 10	5	653	658	3	510	513	4	583	587
10 - 19	8	965	973	2	546	548	5	759	764
20 - 29	19	1,673	1,692	4	1,402	1,406	11	1,535	1,546
30 - 39	7	1,631	1,638	2	1,161	1,163	4	1,387	1,391
40 - 49	7	1,207	1,214	2	818	820	4	1,003	1,007
50 - 59	14	1,160	1,174	14	951	965	14	1,048	1,062
60 and over	23	575	598	17	369	386	20	462	482
Total	12	1,095	1,107	6	801	807	9	944	953

[1] Number of persons injured per 100,000 in each age and sex group.

but the number of persons in this category represented less than 3 percent of the total number of persons injured.

Considered by activity class, over one-half of the persons requiring hospitalization were drivers, one-fourth were passengers, and one-sixth were pedestrians.

TABLE 4

NUMBER OF PERSONS NON-FATALLY INJURED IN ACCIDENTS AND TIME IN HOSPITAL AS THE RESULT OF SUCH INJURIES

Activity	Total Persons Non-Fatally Injured	Persons Hospitalized	Days In Hospital	Average Days In Hospital
Drivers	22,234	3,624	33,804	9.3
Passengers	17,189	1,630	15,020	9.2
Pedestrians	4,545	1,115	10,580	9.5
Others	1,083	278	2,744	9.9
Total or Average	45,051	6,647	62,148	9.4

Worktime Lost

The number of non-fatally-injured persons losing worktime and the amount of worktime lost as a result of motor-vehicle traffic accidents (Table 5) revealed the interesting point that more than one-half of the persons injured did not lose time from work. This situation appeared to be brought about by two factors: First, many injured persons were not members of the labor force, and second, three-fifths of the non-fatal injuries were of a superficial nature. The average number of work days lost per person was 19 days.

TABLE 5

NUMBER OF PERSONS NON-FATALLY INJURED IN ACCIDENTS AND WORKTIME LOST FROM SUCH INJURIES

Activity	Total Persons Non-Fatally Injured	Persons Losing Worktime	Total Work-days Lost	Average Work-days Lost Per Person
Drivers	22,234	13,261	271,170	20.4
Passengers	17,189	4,880	70,795	14.5
Pedestrians	4,545	1,053	23,107	21.9
Others	1,083	211	4,200	20.0
Total or Average	45,051	19,405	369,272	19.0

Of the 22,234 drivers non-fatally injured, 60 percent lost time from work, whereas a similar comparison for passengers and pedestrians shows percentages of 28 and 23, respectively. Of the 19,405 persons losing worktime, drivers accounted for 68 percent; passengers, 25 percent; pedestrians, 6 percent; and others, 1 percent.

PERSONS DISABLED

Table 6 gives the number of persons injured in traffic accidents that were disabled, and the disability rate per 100,000 population. As mentioned earlier, the distribution made according to degree of disability was based on percentage data provided by Utah. On this basis, of the 45,051 persons non-fatally injured in traffic accidents in Massachusetts, 2,117 were permanently disabled to some degree, and 3,514 were temporarily disabled either totally or partially. It is important to note that of all those persons non-fatally injured only 225 suffered total permanent disability, or a rate of less than 5 persons per 100,000 population.

Table 6 also indicates the relative importance of temporary and permanent disabilities in the over-all traffic-accident injury picture. Numerically, disabilities are relatively small but from an economic point of view they account for a sizeable portion of every accident direct cost dollar. Considering the permanently disabled, only a small proportion had total disability. In contrast, almost 65 percent of the permanently disabled group were in the 25 percent disability group.

TOTAL DIRECT COST OF ACCIDENTS

The total direct cost of motor-vehicle traffic accidents is summarized in Table 7 by severity of accident and by cost elements. In considering the direct cost of motor-vehicle accidents it is necessary to distinguish between property-damage costs, which may occur in any type of accident, and property-damage-only accidents. Property damage relates to an element of cost of an accident whereas the property-damage-only accident refers to the severity class of an accident where no injuries were sustained. Total property-damage costs of property-damage-only accidents amounted to $17,900,000, which was almost twice the property-damage costs in total-injury accidents.

TABLE 6

NUMBER OF PERSONS NON-FATALLY INJURED AND THE EXTENT OF THEIR DISABILITY

Degree of Disability	Number of Persons Non-Fatally Injured[1]	Persons Non-Fatally Injured Per 100,000 Population
Permanent disability:		
Total	225	4.7
75 percent	180	3.8
50 percent	360	7.5
25 percent	1,352	28.3
Subtotal	2,117	44.3
Temporary disability:		
Total	2,435	51.0
Partial	1,079	22.6
Subtotal	3,514	73.6
Total disabled	5,631	118.0
Total not disabled	39,420	826.0
Total injuries	45,051	944.0

[1] Distribution of persons according to degree of disability was derived from data provided by the State of Utah, where a similar accident cost study was conducted.

This, however, was to be expected because of the much greater number of property-damage-only accidents. When all the other elements of cost were considered with the property-damage costs, all injury accidents cost 52 percent more than the property-damage-only accidents.

The average accident cost dollar shown in Figure 4 for each severity class and for each of the elements of cost, describes the makeup of the $50,224,000 spent on accidents in Massachusetts during 1953. A most significant fact is that the cost of property damage was greater than that of all other elements of accident cost combined. The minor economic role of the treatment of injuries as a cost element is also indicated.

The "fatal-injury-accident dollar" is representative of the $1,642,000 spent on fatal accidents during 1953. It illustrates the overriding economic importance of damage awards and settlements, which in this instance largely represents the value of human life. The "fatal-injury-accident dollar" also shows that there is a fairly large element of property-damage cost even in this most serious severity class of accident.

The "non-fatal-injury-accident dollar" represents the $28,688,000 spent on non-

TABLE 7

TOTAL DIRECT COST OF TRAFFIC ACCIDENTS BY COST ELEMENTS AND SEVERITY OF ACCIDENT

Cost Elements	Severity of Accident: Fatal Injury	Non-Fatal Injury	Total Injury	Property-Damage-Only	All Accidents
Property damage:	($1,000)	($1,000)	($1,000)	($1,000)	($1,000)
Vehicle	238	9,352	9,590	17,722	27,312
Other property	2	102	104	204	308
Subtotal	240	9,454	9,694	17,926	27,620
Injury treatment:					
Doctors and dentists	25	2,038	2,063	-	2,063
Hospital	24	1,117	1,141	-	1,141
Ambulance	2	56	58	-	58
Miscellaneous	3	139	142	-	142
Subtotal	54	3,350	3,404	-	3,404
Incidental costs:					
Loss of vehicle use	6	105	111	248	359
Value of time lost	32	4,061	4,093	473	4,566
Legal assistance and court fees	293	4,338	4,631	558	5,189
Damage awards and settlements	1,017	7,380	8,397	689	9,086
Subtotal	1,348	15,884	17,232	1,968	19,200
Total	1,642	28,688	30,330	19,894	50,224

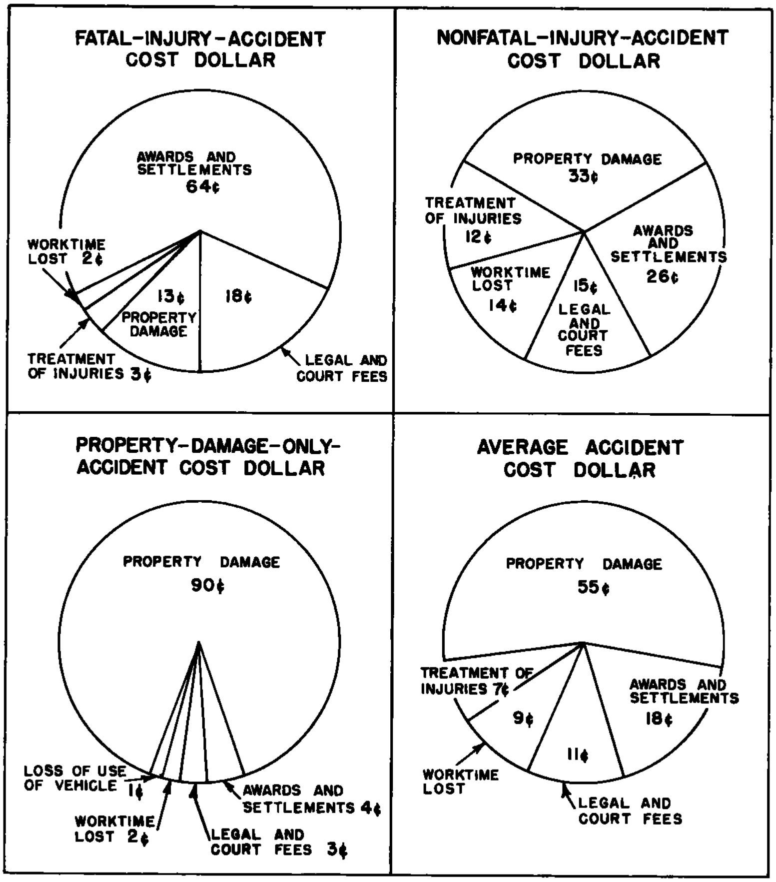

Figure 4. Direct cost of traffic accidents shown as fractional parts of a dollar.

fatal-injury accidents during the 12-month period. In the breakdown of this cost dollar the worktime loss cost more than the treatment of injuries, and property damage accounted for one-third of the total cost of non-fatal-injury accidents. Also, legal and court fees (15 cents out of the dollar) cost more than one-half as much as awards and settlements (26 cents out of the dollar).

The "property-damage-only-accident dollar" is representative of the $19,894,000 spent on property-damage-only accidents during the year. The significant thing about this diagram is that there were elements of cost other than property damage which accounted for 10 cents out of every property-damage-only-accident dollar.

Cost of Injuries by Activity

The direct cost to persons fatally and non-fatally injured in motor-vehicle traffic accidents is given in Table 8 by activity. The study did not provide a breakdown of costs for seriously and superficially injured persons according to their activity, but in total the amounts were $13,906,000 and $5,328,000, respectively. The $20,636,000 cost of injuries is the total direct cost of fatal and

TABLE 8

DIRECT COST OF INJURIES BY SEVERITY OF INJURY AND ACTIVITY

Activity of Persons Injured	Fatally Injured	Non-Fatally Injured[1]	All Persons Injured
	($1,000)	($1,000)	($1,000)
Drivers	156	11,552	11,708
Passengers	378	5,046	5,424
Pedestrians	824	2,305	3,129
Others	44	331	375
Total	1,402	19,234	20,636

[1] $13,906,000—cost of seriously injured; $5,328,000—cost of superficially injured.

non-fatal accidents, less the cost of property damage incurred in them, as given in Table 7.

Over one-half of the total traffic-accident-injury cost was borne by drivers, who experienced approximately twice as much injury cost as passengers. Average injury costs per person involved are calculated to be $524 for drivers, $313 for passengers, $665 for pedestrians, and $343 for all other injured persons.

The average direct cost of injuries sustained by persons in traffic accidents, classified by the severity of injury, is shown in Figure 5. The average cost of a fatal injury was $3,300, which was 4 times the amount expended for the serious non-fatal injury, and 17 times the cost for the superficial non-fatal injury. However, this comparison gives an erroneous idea of the economic importance of fatal injuries unless the total costs and number of persons are considered. The serious non-fatal injuries, in total, cost almost 10 times as much as fatal injuries. Referring to Table 2, there were 18,045 persons seriously injured, as compared to 421 persons fatally injured.

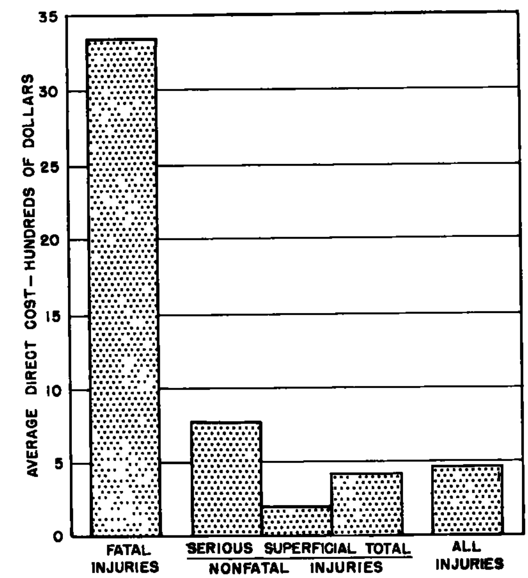

Figure 5. Average direct cost of injuries sustained in accidents, according to severity of injury.

Cost of Injuries by Age and Sex

Table 9 gives the direct cost of injuries to persons in accidents by the severity of their injuries and by their age and sex. It also gives the injury cost rate per 100,000 population for the different groups. Among the important facts observed was that non-fatal injuries, $403,000 per 100,000 persons, cost approximately 14 times as much as

TABLE 9

DIRECT COST TO PERSONS INJURED IN ACCIDENTS AND COSTS PER 100,000 PERSONS, CLASSIFIED BY AGE, SEX, AND SEVERITY OF INJURY

Age of Persons	Males Injured			Females Injured			All Persons Injured		
	Fatally	Non-Fatally	Total	Fatally	Non-Fatally	Total	Fatally	Non-Fatally	Total
Cost to persons injured:	($1,000)	($1,000)	($1,000)	($1,000)	($1,000)	($1,000)	($1,000)	($1,000)	($1,000)
Under 10	112	539	651	50	424	474	162	963	1,125
10 - 19	67	739	804	19	619	638	86	1,356	1,442
20 - 29	147	1,766	1,913	44	1,594	1,638	191	3,360	3,551
30 - 39	96	2,333	2,429	10	1,591	1,601	106	3,924	4,030
40 - 49	81	1,678	1,759	30	905	935	111	2,583	2,694
50 - 59	141	2,074	2,215	42	3,324	3,324	183	5,356	5,539
60 and over	370	1,009	1,379	193	683	876	563	1,692	2,255
Total	1,014	10,136	11,150	388	9,098	9,486	1,402	19,234	20,636
Cost to persons per 100,000:[1]									
Under 10	25	118	142	11	97	108	18	107	125
10 - 19	21	232	253	6	200	206	14	216	230
20 - 29	48	570	617	14	492	505	30	530	560
30 - 39	28	682	710	3	430	433	15	551	566
40 - 49	27	552	579	9	270	279	17	404	422
50 - 59	55	814	869	14	1,124	1,138	33	979	1,012
60 and over	115	312	427	49	174	223	79	236	315
Total	44	439	483	16	369	385	29	403	432

[1] Direct cost per 100,000 persons in each age and sex group.

fatal injuries, $29,000 per 100,000 persons; and that the cost of injuries to males exceeded the cost of injuries to females by 11.4 percent. In the injuries of males, the non-fatal cost was 10 times as great as the cost of their fatal injuries; while in the injuries of females, the non-fatal-injury cost was 23 times as great as the cost of their fatal injuries.

The per capita cost of fatal injuries resulting from motor-vehicle traffic accidents, calculated by dividing injury cost by the number of persons (total population) in each age and sex group, shows that the age groups of 20-29 and over 50 had the highest injury cost rates. The high cost rate in the 20-29 year group would appear to reflect the high injury rate and the greater exposure to accidents of this age group. The extremely high rates for persons over 50 years of age reflects two things: increased earning power that comes with age and experience, and failing physical characteristics that come with age.

The per capita costs of non-fatal injuries resulting from traffic accidents are shown in Figure 6, calculated in exactly the same way used for calculating the per capita cost of fatal injuries. The cost of injuries to males generally increased with age—the 40-49 and the over 60 age groups being the only exceptions. The higher value of worktime lost and the slower rate of recovery in the 50-59 age group are clearly reflected in this Figure.

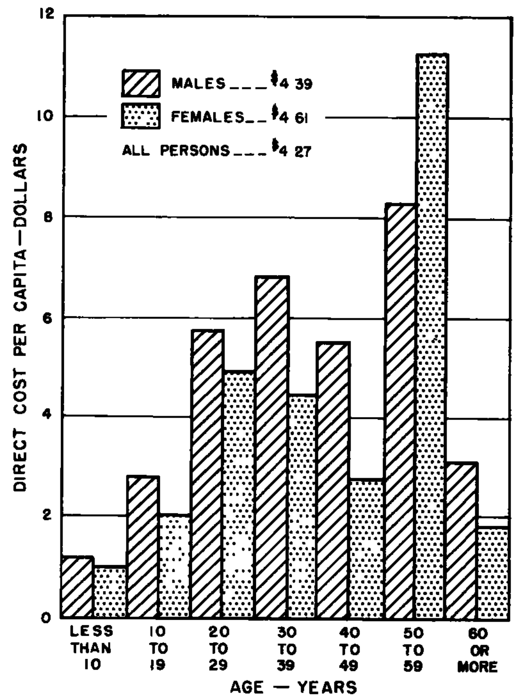

Figure 6. Per capita direct cost, within each age and sex group, of non-fatal injuries.

Economic Cost of Traffic Accidents in Relation to Highway Planning

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This paper points up the value of traffic accident cost data to the highway planner in evaluating and scheduling highway improvement.

It also compares the frequencies and costs of traffic accidents in Utah in 1955 with the results found in the 1953 Massachusetts study. Despite dissimilarities in geographic characteristics and population densities, the relative distributions of accidents in the two States were quite consistent. As to costs, regardless of severity or type, accidents were more costly in Utah than in Massachusetts.

● TODAY, highway planners are seeking more scientific methods of evaluating existing highways and designing and programing new facilities. The highway administrator and planner realize as never before the importance of engineering tools that will permit them to schedule construction on the basis of need, allocate highway funds on a priority basis, select additions to the highway systems, change system classifications, select proper alternate routes or locations, and to cope effectively with public and private groups having vested interests in the processes of planning and programing.

Some states have employed sufficiency ratings to assist them in accomplishing these objectives. This method simply assigns a point rating to each section of road according to its ability to provide traffic service in a safe and efficient manner. Other states have employed economic analyses using factors such as highway costs, revenues, and benefits. In the main, this approach has been simplified to include only the benefit quotient which reflects primarily a savings to the motor-vehicle user in operating cost and time through improved alinement. Some states use both approaches.

In the methods generally in use, one important factor is too often omitted—traffic accident rates. Some states incorporate accident rates in their sufficiency ratings, but more do not. It is known that sections of highway having a good adequacy rating, as provided by the sufficiency rating system, sometimes may have a high traffic accident frequency.

Traffic accident rates normally are not included in economic analyses of the cost-benefit variety at all. The principal reason for the omission has been the unreliability of traffic accident data. Too many accidents are not reported; and for those that are, the reports often do not clearly indicate where the accidents occurred. But one of the greatest deterrents has been the lack of information on accident costs related to the types of vehicles, classes of highways, roadway features, types of accidents, and severity of accidents.

APPLICATION OF ACCIDENT COST FACTOR

Traffic accident data should be one of the highway planner's most important tools to justify street and highway improvements. Just to illustrate this point, a traffic accident study was made on State Street in Salt Lake City. The study section, 17 blocks in length, carried over 30,000 vehicles daily. During a 3-year period, more than 1,000 traffic accidents occurred on this street, and over 700 of them took place at intersections. The street is a 6-lane divided roadway with parallel parking on each side.

It is estimated that had this traffic been carried on a street of freeway design, slightly more than 200 accidents would have been expected instead of 1,000. An Interstate System improvement is being planned to parallel State Street, and the portion paralleling the 17-block study section is expected to carry 100,000 vehicles daily by 1975.

According to the Utah accident cost study, the direct cost for passenger-car accidents occurring on major urban arteries was 0.49 cent per vehicle-mile. Using Utah study data, it was estimated that the direct cost of accidents on the Interstate System would be only 0.13 cent per freeway vehicle-mile. Thus, there would be a savings in accident costs of 0.36 cent per vehicle-mile on streets of freeway design. Based on an estimated traffic volume of 100,000 vehicles daily by 1975, the savings in accident costs would approach $330,000 annually.

The significant point is that an accident cost savings of such magnitude should not be overlooked in justifying an investment of $20 million, as would be required in constructing a freeway parallel to State Street. Furthermore, the savings figure is on the conservative side because it does not include indirect costs relating to traffic accidents.

In this analysis, the reduction in traffic accidents on freeways was based on the California study ("The Economy of Freeways," by Lloyd Aldrich. City of Los Angeles, Street and Parkway Design Division (June 1953)) which indicated that there were five times fewer accidents on their freeways than on local streets. In addition, in the analysis, the accidents expected on the freeway were distributed as to type in accordance with those happening on the Detroit Expressway. This was done in order to isolate those types of accidents that could not occur on a freeway.

UTAH AND MASSACHUSETTS RESULTS COMPARED

The Utah State Road Commission has completed a study of the passenger-car phase of traffic accident costs. It was based on passenger cars registered by the Utah State Motor Vehicle License Bureau in 1955. A sample was selected from the registration list, a universe of 268,000 passenger cars. The registration sample was deemed to be of sufficient size to satisfactorily approximate the general accident experience of the motoring public, but in order to obtain more detailed information on fatal and non-fatal-injury accidents the state's accident files were sampled at a much higher rate than the registration list.

Only a small portion of the data collected in the Utah accident cost study is reported here (Tables 1-4) to provide a comparison of the number of traffic accidents and their costs in Utah and Massachusetts. (A discussion of the Massachusetts data may be found in the article "The Economic Costs of Motor-Vehicle Accidents," by Robie Dunman, HRB Bull. 208.) When comparing the values for the two states, it must be kept

TABLE 1

COMPARISON OF THE NUMBER OF MOTOR-VEHICLE TRAFFIC ACCIDENTS INVOLVING PASSENGER CARS IN UTAH DURING 1955 AND IN MASSACHUSETTS DURING 1953

Item of Comparison	Number of Accidents		Percent of Total		Number of Residents per Accident		Number of Registered Passenger Cars per Accident		Number of Licensed Operators per Accident		Number of Accidents per 100 Million Vehicle-Miles of Travel	
	Utah	Mass.	Utah	Mass.	Utah	Mass.	Utah	Mass.	Utah	Mass.	Utah	Mass.
Severity of accident:												
Fatal-injury	77	315	0.2	0.2	10,350	15,152	3,481	3,933	5,909	5,898	3.1	2.7
Non-fatal-injury	9,048	33,270	19.0	25.3	88	143	30	37	50	56	359	286
Property-damage-only	38,453	97,951	80.8	74.5	21	49	7	13	12	19	1,524	842
All accidents	47,578	131,536	100.0	100.0	17	36	6	9	10	14	1,886	1,131
Type of accident:												
Passenger-car collision with–												
Other motor vehicles	29,044	109,730	61.0	83.4	27	44	9	11	16	17	1,151	943
Pedestrians	1,792	5,848	3.8	4.5	445	809	150	210	254	315	71	51
Fixed objects	741	7,260	1.5	5.5	1,076	654	362	170	614	255	29	63
Other objects	11,921	6,464	25.1	4.9	67	746	22	194	38	290	473	55
Non-collision accidents	4,080	2,234	8.6	1.7	195	2,170	66	563	112	845	162	19
All accidents	45,578	131,536	100.0	100.0	17	36	6	9	10	14	1,886	1,131

TABLE 2

COMPARISON OF DIRECT COSTS OF MOTOR-VEHICLE TRAFFIC ACCIDENTS INVOLVING PASSENGER CARS IN UTAH DURING 1955 AND IN MASSACHUSETTS DURING 1953

Item of Comparison	Total Direct Cost		Percent of Total		Total Direct Cost: Per Accident		Per Capita		Per Passenger Car Registered		Per Licensed Operator		Per Mile of Road		Per 100 Million Vehicle-Miles of Travel	
	Utah	Mass.	Utah	Mass.	Utah	Mass.	Utah	Mass.	Utah	Mass.	Utah	Mass.	Utah	Mass.	Utah	Mass.
Severity of accident:	($1,000)	($1,000)													($1,000)	($1,000)
Fatal-injury	284	1,642	1.2	3.3	$3,690	$5,213	$ 0.36	$ 0.34	$ 1.06	$ 1.32	$ 0.62	$ 0.88	$ 9	$ 67	11	14
Non-fatal-injury	11,559	28,688	49 5	57.1	1,277	862	14.50	6.01	43.13	23.15	25.40	15.44	368	1,171	458	247
Property-damage-only	11,506	19,894	49.3	39.6	299	203	14.44	4.17	42.93	16.06	25.29	10.71	366	812	456	171
All accidents	23,349	50,224	100.0	100.0	491	382	29.30	10.52	87 12	40.53	51.31	27.03	743	2,050	925	432
Type of accident																
Passenger-car collision with—																
Other motor vehicles	17,401	41,816	74.5	83.3	599	381	21.83	8.76	64.93	33.75	38.24	22.50	554	1,707	690	360
Pedestrians	1,417	3,375	6.1	6.7	791	572	1.78	0.71	5.29	2.72	3.11	1.82	45	138	56	29
Fixed objects	271	3,023	1.2	6.0	366	414	0.34	0.63	1 01	2 44	0.60	1.63	8	123	11	26
Other objects	1,880	673	8.0	1.3	158	105	2.36	0.14	7.01	0.54	4.13	0.36	60	27	74	6
Non-collision accidents	2,380	1,337	10.2	2.7	583	608	2.99	0.28	8.88	1.08	5.23	0.72	76	55	94	11
All accidents	23,349	50,224	100.0	100.0	491	382	29.30	10.52	87.12	40.53	51.31	27.03	743	2,050	925	432

TABLE 3

COMPARISON OF THE NUMBER OF COLLISIONS BETWEEN PASSENGER CARS OR PASSENGER CARS AND OTHER MOTOR VEHICLES IN UTAH DURING 1955 AND MASSACHUSETTS DURING 1953, CLASSIFIED BY TYPE OF COLLISION

Type of Collision	Number of Collisions		Percent of Total		Number per 100 Million Vehicle-Miles of Travel	
	Utah	Mass.	Utah	Mass.	Utah	Mass.
Angle	9,911	53,320	34.1	48.6	393	458
Rear-end	10,580	22,501	36.4	20.5	419	193
Head-on	1,117	12,789	3.9	11.6	44	110
Sideswipe (same direction)	2,394	7,114	8.2	6.5	95	61
Sideswipe (opposite direction)	755	1,486	2.6	1.4	30	13
Turning movement	1,876	4,752	6.5	4.3	74	41
Parking maneuver and backing in traffic lane	2,411	7,768	8.3	7.1	96	67
All collisions	29,044	109,730	100.0	100.0	1,151	943

in mind that the base year of the Utah study was 1955, and for the Massachusetts study it was 1953. Because only a two-year difference was involved, no attempt was made to adjust the data to a common year.

The size of Utah is 82,346 sq mi, whereas in Massachusetts the area is 7,867 sq mi. In 1955, Utah had a population of 797,000; there were 268,000 registered passenger cars, 455,000 licensed drivers, 31,400 miles of highways and streets, and 2,523 million vehicle-miles of travel. During 1953, there were 4,773,000 persons living in Massachusetts, 1,239,000 registered passenger cars, 1,858,000 licensed drivers, 24,500 miles of highways and streets, and 11,628 million vehicle-miles of travel.

In comparing the accident rates and costs for the two states, it is quite evident that the results were influenced by such factors as population density, travel speeds, urban characteristics, etc. It is likely that many of the differences could be explained, but to interpret the accident experience of states so widely separated geographically and having such dissimilar characteristics is beyond the scope of this paper. Population density alone would be a major factor to consider in any analysis of traffic accidents. In Massachusetts there were 596 persons per square mile, as compared with 10 in Utah.

TABLE 4

COMPARISON OF DIRECT COSTS OF COLLISIONS BETWEEN PASSENGER CARS OR PASSENGER CARS AND OTHER MOTOR VEHICLES IN UTAH DURING 1955 AND MASSACHUSETTS DURING 1953, CLASSIFIED BY TYPE OF COLLISION

Type of Collision	Total Direct Cost		Percent of Total		Average Cost per Accident		Cost per 100 Million Vehicle-Miles of Travel	
	Utah	Mass.	Utah	Mass.	Utah	Mass.	Utah	Mass.
	($1,000)	($1,000)					($1,000)	($1,000)
Angle	6,596	17,386	37.9	41.6	$ 666	$ 327	261	150
Rear-end	6,058	10,842	34.8	25.9	573	482	240	93
Head-on	1,834	9,078	10.5	21.7	1,642	709	73	78
Sideswipe (same direction)	1,157	1,958	6.7	4.7	483	276	46	17
Sideswipe (opposite direction)	351	706	2.0	1.7	465	471	14	6
Turning movement	486	1,114	2.8	2.7	259	232	19	10
Parking maneuver and backing in traffic lane	919	732	5.3	1.7	381	94	36	6
All collisions	17,401	41,816	100.0	100.0	599	381	690	360

In spite of the dissimilarities of the two states, however, there is remarkable consistency in the relative distribution of accidents when classified according to severity and type. The most common method of comparison is to express the number of accidents and their cost in terms of 100 million vehicle-miles of travel. This is done in the last two columns of the tables. In general, accidents were costlier in Utah than in Massachusetts, regradless of severity or type of accident or type of collision.

An attempt to draw conclusions on the basis of the data presented here for two strikingly different states would not be justified, but certainly the results add significantly to the knowledge needed to develop national trends of traffic accidents.

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