# HIGHWAY ACCIDENT COSTS AND RATES IN TEXAS

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The opinions, findings, and conclusions expressed in this publication are those of the author and not necessarily those of the Texas Highway Department or the Federal Highway Administration.

## ABSTRACT

This study develops a method of estimating costs for selected Texas accidents using cost data developed for accident involvements in Massachusetts, Illinois, New Mexico and Utah. Given the number and type (car/truck) of vehicles involved and the number of fatally injured persons, accident costs can be derived using the direct cost per involvement and loss of future earnings estimates presented in the report.

Also, accident rates for selected highway designs and for various average daily traffic counts are presented and analyzed.

SUMMARY

This report develops and utilizes a method for estimating Texas accident costs utilizing involvement cost data from studies completed by the states of Massachusetts, Illinois, Utah, and New Mexico.

The data from these states are combined into a single data system employing a classificatory method which uses the following categories:

1. Accident severity
2. Accident type
3. Rural - urban location
4. Vehicle type
5. Highway type
6. Highway system
7. Highway characteristics

For these classifications and selected cross-classifications, costs per involvement are derived and adjusted by price indices to yield comparable dollar results.

The accident experience in Texas is determined by classifying the vehicles involved in accidents in 1969 according to the same categories used by the four states. The resulting frequencies of involvements are combined with frequencies of selected accident situations to generate a set of weights to be applied to the costs per involvement. This yields a set of accident cost estimates for accident situations defined by the following characteristics: severity, accident type, location, and vehicle-type combination.

For inclusion in the cost components of fatal accidents, estimates for the present value of expected future earnings are developed to represent the minimum dollar loss due to the occurrence of a traffic fatality. This indirect

cost component is added to the direct cost of fatal accidents to give a more comprehensive estimate of the money damages caused by accidents.

Finally, an exploratory examination is made of accident rates on rural segments of Texas highways. These rates are computed using highway type, accident severity, and average daily traffic categories. The results are presented and discussed briefly.

## IMPLEMENTATION STATEMENT

Accident cost data can be used as an input in cost-effectiveness and/or benefit-cost analyses of traffic safety programs, alternative highway designs, and spot improvement projects. The involvement and accident cost data developed in this report can serve a variety of needs.

First of all, the data are presented on the basis of accident severity. When the accident severity mix of a particular program or project cannot be determined, the set of estimates for all severities can be used.

Cost estimates are also provided for use when the location, type of accident, and vehicle-type combination are known.

Since involvement costs by highway type, highway system, and road characteristics have been estimated, the user who desires accident cost data for these categories can develop his own if he has data on the number and type of vehicles involved and, in the cases of fatalities, the number of persons fatally injured.

The data give the user the flexibility of including or excluding the loss of future earnings component in the case of fatal accidents.

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# INTRODUCTION

Increasingly, decisions regarding outlays of funds for highway improvement projects and new construction are being based upon information that can be placed into a cost-benefit type of analytical framework. The types of cost to be included depend upon the nature of the project but can range from such clearly recognized items as cost of construction materials to the more complex item of, for example, social costs of dislocation of business firms and persons. The availability of such cost information for use as input into the decision-making process tends to be negatively associated with the difficulty in obtaining it. Thus, the existence of information on right-of-way costs, for example, reflects an established system of records containing cost elements. On the other hand, data showing the societal cost of relocation due to construction is difficult to obtain because of the conceptual problems of measurement and the lack of a developed system of gathering the requisite information. Perhaps this dichotomy offers useful insight into the paradox which exists with regard to accident information *vis-a-vis* accident *cost* information. In spite of the fact that a wealth of information has been collected on the occurrence of accidents, the corresponding accident cost data are relatively scarce. In an attempt to fill some of the existing gaps, the main objective of this report is to provide some usable cost estimates for accidents occurring on Texas highways. A secondary objective is the development of some accident rates for various type of Texas highways.

Several comprehensive accident cost studies in the United States have been made during the past two decades. This development began with a 1949 publication by the Bureau of Public Roads which set up an operational framework to be used in the conduct of accident cost studies. With the aid of the Bureau, the State of Massachusetts undertook a comprehensive analysis of the costs involved in its 1953 accident experience. Since then Utah (1955-1957), New Mexico (1955-56), and Illinois (1958) have completed and published the results of their statewide studies. At least one other state highway department, Ohio, has conducted a similar study, and has just published the final results.[1] In addition to these statewide studies, an accident cost analysis has been conducted for the District of Columbia and its surrounding counties in Maryland and Virginia.

Each of these accident cost analyses was the product of an extensive questionnaire - interview process in which individuals involved in accidents were queried to determine the direct cost of their involvements. Included in the total cost per involvement were the following major cost components: (1) property damages to vehicles, vehicular cargo, and non-vehicular property; (2) medical costs to include doctor fees, hospital charges, drug, medicine, and appliance charges, and ambulance service charges; (30 legal and court costs; (4) value of work time lost due to non-fatal injuries; and (5) miscellaneous costs.

Each of these states made its raw data available to the Bureau of Public Roads, and in 1968 the Burearu completed its work of reorganizing the data to insure its mutual compatibility among the states. These

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[1]The Ohio Study, dated 1970, was received too late to be incorporated analytically into this report.

data were provided by the BPR for use in this study and serve as the basis for the cost estimates of Texas accidents.

The general nature of the study as reported herein is fairly straightforward: determine the average (mean) cost for an accident having stipulated characteristics[2] and adjust these costs for time and place differentials. The resulting cost figure is an estimate for a similar accident in Texas having those same characteristics. Thus, to estimate the cost of a Texas fatal accident occurring on a 2-lane road when two vehicles hit head-on, this procedure would entail the calculation of the costs of such an accident occurring in the 4 states and the adjustment of this cost for time and place differences. The apparent simplicity of such an exercise glosses over several difficulties which must be understood as a prerequisite to a proper interpretation of the study's results. The following section explores some of the basic concepts and assumptions under which the study was conducted.

## Basic Concepts and Definitions

Ideally, the determination of accident costs would be made by using the individual traffic accident as the basic statistical unit over which a sample would be taken. Such a procedure is operationally difficult to implement when more than one vehicle is involved, since the cost calculations would depend upon obtaining information from (at least)each driver involved. Such a sampling procedure would be operationally difficult to implement to obtain estimates for the costs of accidents involving multiple vehicles, since the expense of

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[2] A, B, C, D, might be, e.g., rural, passenger car, head-on, fatality.

locating the accident participants and obtaining usable information about the costs incurred by drivers, persons injured or killed, and other property owners involved in a multi-vehicle accident likely would be considered prohibitive. Consequently, an alternative procedure was developed using the involvement rather than the accident as the basic statistical unit. Therefore, a careful distinction must be made between the concepts of accident and involvement.

A traffic accident is any accident involving one or more vehicles in motion which occurs on a traffic-way and results in death, injury, and/or property damage. An involvement is that portion of an accident relating to a single vehicle and the death, injury, and/or property damage associated with that vehicle. By way of example, assume that two vehicles, a passenger car and a truck, collide head-on resulting in death, injury, and property damage in the car and property damage in the truck. Such an outcome produces one accident and two involvements--a passenger car involvement and a truck involvement. The necessity for making this distinction is implicit in the sampling and data collection techniques of the data-states.[3]

The sampling process used two basic sources of data: reported accident files and motor vehicle registration files. The reported accidents were sorted on a severity basis--fatal, injury, property damage only. Thus if a person was killed in a multi-vehicle collision, the accident and <u>all</u> of its component involvements would be classified in the fatality category. Interpretations of involvement data should be made keeping

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3
Data-states hereafter will be used to refer to Illinois, Massachusetts, New Mexico and Utah.

in mind that the severity classification of the involvement was determined by the severity of the accident.[4] Hence, a fatal (injury) involvement may or may not have included the fatality (injury) upon which the accident classification was based.

Since the data-states all used the involvement as the basic unit of study, the discussion of accident costs, for our purposes, necessitates the conversion of costs from an involvement to an accident basis.[5] An explanation of this conversion (along with the inherent problems of doing it) is presented in the Research Method section later in this report.

Cost Elements

The criteria for the selection of the elements to be included in the involvement cost estimates are based upon the distinction, first made by the Bureau, between direct and indirect costs.[6]

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[4]The general rules for assigning an accident to a severity class are: fatality - an accident in which one (or more) person is killed; injury - an accident in which one (or more) person is injured, but not fatally; property damage - an accident in which no fatalities or injuries occur.

[5]Not processing their information in a cost-per-involvement manner, the data-states reported on total involvement costs. The recently published report of the Ohio study presented involvement costs both as averages and totals.

[6]BPR Manual, p. 9, et. seq., the exposition of these and other cost concepts draws heavily from this document.

Generally, direct costs include the money value of damages and losses to persons and property which are the direct results of accidents and are composed of the following items:

1. Cost of damage to property
2. Cost of injuries to persons
3. Value of time lost
4. Cost of loss of use of vehicle
5. Legal and court costs
6. Damage awards in excess of costs
7. Miscellaneous costs

A brief explanation of each item will indicate the scope of the expenses which are included. (1) Damage to property includes costs of repairing or replacing damaged motor vehicles, cargo, property outside the vehicle, and highway furniture. (2) Injuries to persons is composed of costs for emergency ambulance service, hospitalization, physician and nursing services, other treatment, and ambulatory and prosthetic devices. These costs for fatally injured persons are calculated only up to the time of death. (3) Value of time lost is the measure of income foregone due to incapacitation. It is calculated only for those injured persons who are employed and not permanently and totally disabled. Additionally, expenses in the form of time lost of persons having vehicles repaired, making required court appearances, caring for injured persons, etc., are considered as direct costs. Finally, the problem of incapacitated housewives deserves attention since they are not included as part of the labor force. Consequently, any expenditures for a temporary house-keeper, nursemaid, etc., represent an imputation of the value of a housewife's services and is properly included as a direct cost element. (4) Loss of use of vehicles, in the case of a private, non-commercial owner, covers the outlays for alternative transportation until the damaged vehicle is replaced or repaired. For a commercial vehicle owner, loss due to an out-of-service vehicle is the amount of net earnings of the vehicle during the period not in use.[7] (5) Expenditures for lawyers, court costs, and other legal fees and excess damages awarded are also calculated as direct costs. Excess damages are a residual and arise when the court award exceeds the sum of the other direct costs. When the amount awarded by the court does not exceed the sum of the other direct cost elements, the category "excess damages" is not included. Finally, (6) miscellaneous expenses includes all other direct costs not previously accounted. Such things as transportation under a doctor's order of an injured person to and from hospitals and/or convalescent facilities would be a miscellaneous cost.

In summary then, direct costs include those expenses (primarily "out-of-pocket") which can be directly attributable to accident occurrences. Since the data-states relied exclusively on the direct cost components as their source of involvement cost estimates, little will be said about the other major cost category--indirect costs.[8] There is, however, at least one indirect cost item that should be discussed if for no reason other than the magnitude of the dollar value it entails.

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[7]For a more esoteric discussion, see Ibid., p. 16.

[8]For a full description of indirect cost items see Manual, pp. 21-31.

The loss of future earnings due to death or permanent and total disability represents the dollar amount of potential output of goods and services that is lost to society when one of its members dies or is rendered unemployable as a result of an accident. The introduction of such an item brings forth, at least implicitly, the notion of a measurement for the value of a human being and all its attendent philosophical and moral trappings. Given these difficult problems, the decision to include or exclude the loss of future earnings has a very significant impact on the estimated cost of fatal involvements.[9] In reflecting only the direct costs, the costs for fatalities reported by the data-states might be interpreted best as representing some set of minimum values. To these minima could be added a loss of future earnings estimate. The result would be a better estimate of the costs of fatal involvements. At any rate, the quantitative difference brought about by the exclusion or inclusion of this item is large enough to warrant special consideration.[10]

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[9] For example, the Ohio study shows $4,236 as the average cost per fatal passenger car involvement and the Washington Area Study shows $49,435. [See: Ohio Department of Highways, The Analysis of Motor Vehicle Accident Costs in the State of Ohio, (Columbus: The Ohio State University), 1970, p. 32, Table 4-1, hereafter referred to as the Ohio Study; and Wilbur Smith and Associates Motor Vehicle Accident Costs; Washington Metropolitan Area, (Washington: Wilbur Smith and Associates, 1966, p. 77, Table 48, hereafter referred to as the Washington Area Study.]

[10] See Research Method section following.

# RESEARCH METHOD

## Costs - General

The essential feature of the method used for determining accident costs for Texas is its reliance on the data collected in other states at different points in time. As indicated in the Introduction, the approach utilizes cost information gathered in the data-states to estimate the mean costs for various kinds of accidents occurring in Texas in 1969.

The theoretical argument which constitutes the foundation for usage of the method goes something like this: the magnitude of the direct cost for any given accident is dependent upon (a) the cost per unit of the relevant components (e.g., dollars per hospital day, dollars per wrecker mile, dollars per hour mechanical labor, etc.) and (b) the number of units involved (e.g., 20-day hospital stay, 50-mile wrecker tow, 3 hours labor in repair shop, etc). Thus a & b represent the more familiar price-quantity concepts used in economic analysis. Since the total direct cost of an accident is the sum of the various components, the set of prevailing prices for the relevant items is a very important element in the ultimate determination of accident costs.

On the other hand, the quantity (or number) of the items which result from an accident (i.e., number of hospital days, number of hours for automotive repair, number of cars needing replacement, etc.) is a function of the physical characteristics of the accident including, for example, number of vehicles, type or manner of collision, number and type of personal injuries, and speed.

Consequently, for an accident with a given set of physical characteristics, the direct cost will vary with changes in the set of prices. Obversely, for a given set of prices, the direct cost will vary with changes in the physical characteristics of the accident. Conceptually, it is a simple matter to estimate the costs of accidents occurring in one state from the (known) costs of similar accidents in another state. The problem is one of matching accidents having identical physical characteristics and adjusting the known costs to reflect any differences between the sets of prices for the two states. The effect is simply to transfer a known cost from one state to another adjusting the result for price differentials due to time and place displacement.

Operationally, however, the implementation is far from being the tidy procedure just described. The first difficulty arises when the question is asked: what exact price deflator appropriately reflects the price changes of those items which are components of direct cost? Needless to say, none exists. Necessarily, then, any price deflator which is used will yield results which are somewhat distorted in the process of adjustment.[1] A more difficult problem is faced in determining the extent to which the physical characteristics of an accident in one state must correspond to the physical characteristics of an accident in another state before the two accidents can be considered the same for purposes of transferring the costs from one state to another. For example, suppose two accidents occur and are identical in every respect except that one happened at midnight, the other 3:00 a.m. Given that the only difference is one of a 3-hour lag in time of occurrence, the direct costs of the two

[1] See Irving Fisher, The Making of Index Numbers (New York: A. M. Kelley, 1967).

accidents are probably the same. The extremity of this hypothetical example points toward the necessity for placing accidents in like categories defined by arbitrarily selected physical characteristics, since the occurrence of accidents alike in every respect is probably a rarity. The focus of the method must shift toward the selection of those physical characteristics which will result in a categorization of accidents that tends to group accidents similar in cost.

In its purest form, such a categorization could result in a complete theory of accident costs in which the magnitude of the dependent variable, direct costs, is determined (assuming a given set of prices) by the independent variables, the physical characteristics. The method used here, however, does not propose such an encompassing treatment of the (physical) cause and dollar effect relation.

The characteristics obtained to systematize the cost data for presentation were chosen on the basis of: (1) their hypothesized importance in determining involvement costs; and (2) the type of information available from the data-states. For example, vehicle speed reasonably could be hypothesized as an important determinant of involvement costs, e.g., the higher the speed of an involved vehicle, the higher the involvement cost. Nevertheless, since vehicle speeds are not among the information provided by the data-states, direct classification of involvements according to speed is not possible. A less direct way of accounting for the influence of speed upon the resulting costs is possible by utilizing a rural-urban dichotomy, as rural travel implies higher speeds than urban travel.

As a result, the classification scheme which is used reflects the need to combine analytical categories with categories determined by data availability. This was accomplished with the additional consideration of developing results which could be utilized as input for cost-effectiveness and/or benefit-cost analyses.

Assumptions and Definitions

The most important characteristic of an involvement is probably its severity. Whether persons were killed, injured, or unharmed affects the magnitude of both the direct and indirect costs of the involvement. A classification of fatal, injury, or property damage would be expected to show increasing costs from the least (property damage) severe to the most (fatal) severe. Since the entire system of classification of involvements revolved around the severity category it is of some importance that cost-per-involvement for a given severity be approximately the same in each of the data-states. If this is so, then there is some empirical support for the critical assumption which is the foundation of this study, that the direct cost of an involvement having certain physical characteristics can be adequately estimated by the average cost of other like involvements.

To determine the similarity of the involvement costs for a given severity among the data-states an analysis of variance was made.[2] This test indicated that at the 5% level of confidence there was no significant difference in the mean cost among the data-states for the involvements which were tested. These results provided empirical justification for

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[2] The formulation and results of this test are presented in Appendix A.

combining the data from the data-states and treating them as a single data system from which to estimate costs of Texas accidents.

A less rigorous indicator of the efficacy in using severity classes to analyze accident-involvement costs is the similarity among states with respect to the number of persons killed/injured in accidents. The following chart indicates this similarity:

Persons Killed Per Fatal Accident and Injured Per Injury Accident

| State | Rural Accidents | | Total Accidents | |
|---|---|---|---|---|
| | Fatal | Injury | Fatal | Injury |
| Illinois | 1.28 | 1.69 | 1.23 | 1.61 |
| Texas | 1.29 | 1.78 | 1.21 | 1.79 |
| Massachusetts | - | - | 1.30 | 1.90 |
| California | 1.28 | 1.69 | 1.23 | 1.61 |

Sources: Texas Department of Public Safety, Motor Vehicle Traffic Accidents 1969, (Austin, Texas: Texas Department of Public Safety, March 1970), p. 7; Robie Dunman, "Economic Cost of Traffic Accidents in Relation to the Human Element," Economic Costs of Traffic Accidents, Bulletin 263, (Washington: Highway Research Board, 1960). p. 41; and Richard N. Smith and Thomas N. Tamburri, Direct Costs of California State Highway Accidents, (Sacramento, Calif: California Division of Highways, 1967), p. 14.

Since the number of persons killed or injured greatly affects the size of the medical component of direct costs, the extent to which the number of persons killed (injured) per fatal (injury) accident are alike among different states is likely to effect a degree of similarity in the cost of these fatal and injury accidents. Interpreted thus, the data in the chart above provide additional empirical justification for the analysis of a single data system (i. e., the combined input of the data-states) using the severity category to classify like involvements.[3]

Other classificatory characteristics, in addition to accident severity, were chosen to provide a framework for organizing and presenting the data. As with severity, these were selected according to three primary criteria: (1) the hypothesized relationship between costs and physical characteristics of involvements (i.e., a head-on, multi-vehicular collision has higher costs than a vehicle-animal collision); (2) the availability of data; and (3) the need for results that could be used as input for cost-effectiveness and benefit-cost analyses. The selected categories are: (1) accident type; (2) vehicle type; (3) type of area (urban-rural); (4) road characteristics; (5) road type; and (6) highway system. Each of these will be discussed separately.

Accident type refers essentially to the manner in which an accident occurred. To a large degree, it also indicates whether accidents involve single or multiple vehicles, although there is some ambiguity regarding this matter. Proceeding definitionally, there are 13 different types of accidents: head-on, sideswipe, rearend, and turning describe multiple motor-vehicle collisions; whereas collisions with pedestrians, bicycles, trains, animals, fixed objects and other

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[3] In comparing the results of the accident cost studies of Utah and Massachusetts, it was noted that: "In spite of the dissimilarities of the two states...there is a remarkable consistency in the relative distribution of accidents when classified according to severity and type." see: J. Edward Johnston, "Economic Cost of Traffic Accidents in Relation to Highway Planning," Economic Costs of Traffic Accidents, Bulletin 263, (Washington: Highway Research Board, 1960), p. 53.

objects tend to involve single motor-vehicles only. The most ambiguous (with respect to the single or multi-vehicle criterion) accident type is that which categorizes all accidents not involving a collision, e.g., running off the roadway, and may involve one or more motor vehicles.

The type of vehicle is initially segregated on the basis of a passenger car-truck criterion with trucks further classified as single-unit (e.g., pick-up, bob-tail, etc.) or combination-unit (e.g., tractor-trailer).

The rural-urban category, although referred to herein as a population characteristic, is not strictly defined by population counts. The key criterion is whether or not an accident took place in an unincorporated locale. If so, the accident is reported as a rural accident; if the area in which an accident occurred was incorporated, it is an urban accident. Since unincorporated areas are likely to be sparsely populated, i.e. rural, the use of incorporated and unincorporated as surrogates in specifying the rural-urban dichotomy seems adequate.

The remaining categories-road type, road characteristics, and highway systems-were selected primarily to provide more finely detailed information that might be of use to highway analysts. In this attempt, involvements and costs are classified and presented using the following criteria to delimit road type: (1) number of traffic lanes; (2) traffic direction, one-way or two-way; and (3) traffic separation, divided or undivided. Traditionally, highway systems have been classed as Federal-aid primary, Federal-aid secondary, and non-Federal-aid; and that grouping has been adopted in this study.

Completing the discussion of categories, the classification of involvements with respect to certain road characteristics represents an effort to specify costs resulting from the occurrence of accidents at prominent roadway features: intersections, curves, bridges, railroad crossings, interchanges, tunnels, and underpasses. Since these headings are not completely mutually exclusive, there exists some conceptual ambiguity, e.g., how to classify an accident occurring on a curve which contains an intersection. Although the extent to which this type of ambiguity is present in the data is unknown, its effects are assumed to be of negligible importance.

Briefly summarized, the basic approach consists of combining, via several classificatory characteristics, the accident data of the data-states into categories from which cost estimates can be made. The next section discusses the computational and statistical aspect of the research method.

To estimate the direct costs of vehicle involvements, the data are categorized on the basis of the criteria discussed above, adjusted for cost differentials due to inflation, and converted into weighted means. The resulting data-base is designed to assure its compatibility with the sampling procedures used by the data-states in collecting the raw information.

<u>The Data-Base</u>

In generating the original data, each of the data-states used a sampling procedure designed to adequately represent its total accident experience. Generally, this procedure entailed two phases: (1) a sampling of reported accident files primarily to insure adequate coverage of fatal and injury accidents; and (2) a sampling of motor vehicle registration files primarily to yield adequate coverage of property damage accidents, particularly those of a relatively "mild" nature that tend to be unreported or under reported. Two sets of these samples were obtained in each state, one for passenger cars and the other for trucks.[4]

For purposes of the present study, the most important comparable feature in the sampling procedures of the data-states is that severity categories were used to define the strata for subsequent differential sampling. Thus, for reported accidents, accident report files were separated according to the fatal, injury, and property damage criterion. Each of these strata was then sampled using a sampling rate which yielded a desired level of statistical accuracy.[5]

To treat the information from the data-states as a single data-base, it is necessary to combine the data in a manner that is compatible with the sampling procedures used by those states. To this end, the statistical treatment of the resulting data-base is somewhat constrained. Such constraint that exists is manifested in the following ways: involvements are first segregated into severity classes before further classification is accomplished; and, inversly, severity classes are not combined in the process of deriving cost estimates.

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[4]For a more detailed discussion see C. M. Billingsley and D. P. Jorgenson, "Direct Costs and Frequencies of 1958 Illinois Motor-Vehicle Accidents," Highway Economics, Highway Research Record No. 12, (Washington: Highway Research Board, 1963) pp. 49-52; and Illinois Department of Public Works and Buildings, Division of Highways, Cost of Motor-Vehicle Accidents to Illinois Motorists, 1958, (Springfield: Illinois Division of Highways, 1962), Technical Appendix , pp. 131-159.

[5]See Appendix B for a list of sampling rates used by the data-states.

This procedure is used because, in the context of a combined data-base, the sampling rates of the individual data-states cannot be utilized in determining mean involvement costs. These rates were determined by the characteristics of the accident population of the respective states and along with the resulting expansion factors (used to expand state samples into state totals), have quantitative meaning only with respect to the individual state.

On the other hand, when the involvements of the data-states are grouped by severity, the implicit assumption is that these involvements are from populations which include only involvements of like severity. Thus, a fatal involvement in Illinois and a fatal involvement in Utah are viewed as equivalent observations from the population of fatal involvements.

The most important aspect of this treatment is the limitation which it places on the interpretation of the resulting mean cost estimates. While it is possible to determine the mean cost of selected involvements of like severity, it is not possible to derive the mean cost of selected involvements of differing severities. In the former case, the involvements are equally weighted; in the latter, no weights can be assigned since the exact nature of the quantitative relationship (in the combined data system) among the severity categories cannot be specified due to the different sampling rates selected for the original studies.

The decision to keep involvements homogeneous with respect to severity obviates the need for assigning differential weights to reported involvements. However, when non-reported involvements are included, it becomes necessary to make adjustments to account for the disparate rates of occurrence of reported and non-reported involvements within a given severity category. This is so because the non-reported involvements in the original studies were sampled (from the registration files of vehicles) without regard to severity classes. Consequently, in building the data system for the present study, non-reported involvements have been assigned weights to yield a more accurate mix of reported and non-reported involvements than is presented by the data in raw, unweighted form.[6] The effect of this weighting mechanism is most apparent in the property damage only severity class since unreported involvements seldom entail more than property damage.[7]

Involvement and Accident Costs

In determining the average cost of involvements, the direct cost components must be adjusted via a price index in order to convert costs into comparable magnitudes. Since price indices are not constructed

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[6] The weights chosen are based on the expansion factors used by the data-states and are determined by the following ratio:

$$\frac{\text{Expansion Factor of Unreported Involvement}}{\text{Expansion Factor of Reported Involvement}}$$

See Appendix B for a listing of the weights used.

[7] For example, the percentage of non-reported passenger-car involvements accounted for by property damage only involvements is: Illinois-94%; New Mexico-95%; and Utah-82%. Massachusetts sampled all property damage involvements at the same rate with the result that the non-reported involvements could not be separately identified. Also, for a complete description of the quantitative relationship between reported and non-reported involvements in Illinois see: Billingsley and Jorgenson, *op. cit.*, Table 2, p. 52.

on an individual state basis, adjustments for relative cost differentials among the states cannot be made. To adjust for price differences due to time differentials, two price indices are used - the overall Consumer Price Index (CPI) and the medical cost component of the CPI.[8]

The direct cost items containing medical, hospital, physician, and nursing fees were adjusted by the medical cost component of the CPI. All other direct costs were adjusted by the overall CPI.

After the direct costs are adjusted for price level changes, the mean cost of the involvements (as defined by the relevant characteristics) is calculated. The resulting average is the estimate of the mean cost of the population of involvements having those defining characteristics. Further, to indicate the degree of variability in the data, the standard error of the mean is calculated.[9] This standard error is an imput which can be used to establish confidence intervals for the estimates. It is also used to calculate the measure of relative error (ratio of the standard error to the mean multiplied by 100) which is useful in making relative comparisons of data variability. Both of these measures reflect the statistical reliability of the estimates and, as such, can be important to users of the cost estimates developed herein.

Loss of Future Earnings

To derive a measure for loss of future earnings for fatally injured persons, estimates are made using data developed by Weisbrod in his analysis of the economic costs of diseases.[10]

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[8] See Appendix C for a list of the weighting factors used for these adjustments.

[9] See Appendix A for standard formula used in these calculations.

[10] Burton A. Weisbrod, Economics of Public Health, (Philadelphia: University of Pennsylvania Press, 1961), Table 3, pp.60-61.

Weisbrod's present values of net future earnings (discounted value of expected future earnings minus expected consumption) are adjusted by the overall CPI to bring them up to date.[11] To account for the age and sex composition of those persons killed in Texas accidents in 1969, a weighted-average is calculated. This weighted-average represents the loss, in money terms, attributable to a highway fatality.

While the price index adjustment is assumed to be correct for increases in earnings (including inflationary and productivity changes), two other factors are present which probably cause the resulting fatality cost to be undervalued. The first of these is due to changes in life expectancies. Weidbrod's calculations employed actuarial data obtained in 1961. In the ensuing years, life expectancies have lengthened, and estimates based on his data are probably undervalued. Secondly, in subtracting consumption expenditures from earnings, Weisbrod chose to ignore the value to a deceased person of his own consumption activities. Another method would be to use the present value of gross future earnings, which is philosophically different from and yields quantitatively larger results than the method used herein. At any rate, the net effect of these two factors is to generate values for losses due to fatalities that are lower than they might and/or should be.

Accident Costs

Given direct cost per involvement and cost per fatality as calculated above, the costs of selected Texas accidents can be determined by combining the involvement costs and fatality costs in proportions indicated by information describing the 1969 Texas accident, involvement, and fatality

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[11] See Appendix C.

experience. This latter information is obtained from two sources: (1) the 1969 accident tape provided by the Texas Highway Department which includes all accidents reported to the Texas Department of Public Safety in 1969; and (2) the annual accident summary published by the Department of Public Safety.

Texas involvements are coded to match the defining characteristics of the involvements from the data-states.[12] Additionally, selected accident frequencies have been determined using severity, accident type, rural-urban, and vehicles involved as the defining characteristics.

To determine cost per accident, the number and type of involvements (e.g., one car and one truck in a car-truck accident) are multiplied by their respective average direct costs per involvement and then added together. The result is the estimate for the direct cost of that accident category.[13] If the accident is also defined as fatal, another cost component, loss of future earnings, will be added. This amount is equal to the cost per fatality multiplied by the number of fatalities.

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[12] The correspondence between Texas and the data-states' involvements is not complete, however. Two defining characteristics - road type and highway system - are not coded on the Texas accident tape. Another tape, RI-2, contains information on road type and highway system for Texas highways. RI-2 was made available for use in the present study, but due to the expense involved in matching all the accidents (on the accident tape) with the road type/highway system (on RI-2), usage of the RI-2 is confined to the accident rate portion of this study.

[13] Variations of this technique are used in the Ohio and California studies, but neither included a subsequent component for the loss of future earnings resulting in fatal accidents.

## INVOLVEMENTS AND INVOLVEMENT COSTS

The data in this section are of two kinds: (1) direct cost per involvement as determined via the method outlined in the preceding section; and (2) involvement frequencies in Texas during 1969. In tabular form, the mean costs and the respective standard errors of the estimates of the mean are presented for the various sets of characteristics which have been used to group the data for purposes of estimation.

In general, the highlights of the data are pointed out. But, since the scope of the work does not include a comprehensive explanation of the physical cause and dollar effect, detailed explication is not attempted. The data are presented in the following order:

Passenger car costs (Tables 1-7)
Truck costs (Tables 8-14)
Passenger car involvements - Texas (Tables D1-D5).
Truck Involvements - Texas (Tables D6-D15).

### Direct Costs per Involvement

Passenger Cars: The data shown in Table 1 are the "highest-level" aggregates which have been computed for passenger cars. Only accident-type and severity were defining characteristics; consequently, the resulting estimates are based upon the greatest number of observations obtainable from the data-states' information. Given the relatively large number of involvements per cell, the results in Table 1 tend to be the most reliable of the passenger car cost estimates.[14] As the

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[14] In fact, the totals in Table 1 yield relative errors of 5.3 (fatal), 3.5 (injury), and 1.4 (property damage) which compare quite favorably with the 7.0 relative error established in the Washington Area Study, p. 220.

Table 1

Direct Cost per Involvement, Passenger Cars, by Accident Type and Severity, Data-States

| Accident Type | Fatal | Severity Injury | P.D.O. |
|---|---|---|---|
| Multi-Vehicle: | | | |
| Head-on | $8,593 | $1,518 | $235 |
| Std. Error (S.E.) | $1,469 | $ 223 | $ 11 |
| Rear-End | 6,482 | 1,000 | 161 |
| S.E. | 1,432 | 62 | 4 |
| Angle | 6,505 | 950 | 198 |
| S.E. | 644 | 42 | 5 |
| Sideswipe | 6,946 | 594 | 131 |
| S.E. | 2,299 | 80 | 9 |
| Turning | 5,232 | 945 | 169 |
| S.E. | 1,439 | 87 | 6 |
| Parking | - | 485 | 66 |
| S.E. | - | 95 | 3 |
| Other | 7,731 | 862 | 123 |
| S.E. | 4,523 | 161 | 6 |
| Single-Vehicle: | | | |
| Pedestrian | 5,395 | 1,441 | 28 |
| S.E. | 329 | 206 | 5 |
| Train | 6,846 | 1,834 | 439 |
| S.E. | 986 | 733 | 163 |
| Bicycle | 4,518 | 1,006 | 61 |
| S.E. | 678 | 402 | 13 |
| Animal | 3,066 | 1,878 | 308 |
| S.E. | 1,650 | 424 | 23 |
| Fixed-Object | 3,057 | 1,934 | 273 |
| S.E. | 308 | 278 | 19 |
| Other-Object | 5,578 | 1,139 | 91 |
| S.E. | 4,262 | 164 | 2 |
| Non-Collision | 3,909 | 1,681 | 219 |
| S.E. | 508 | 118 | 12 |
| ALL | $5,574 | $1,137 | $165 |
| S.E. | $ 295 | $ 40 | $ 2 |

data are disaggregated, the standard errors increase, reflecting the reduction in the number of observations utilized for estimates of the disaggregated data.[15]

The average costs of passenger car involvement are (from Table 1): \$5574-fatal; \$1137-injury; and \$165 property damage only. For fatal involvements, the most costly is that resulting from a multi-vehicular, head-on accident. The least costly is from a single-vehicle, fixed-object collision. As might be expected, the multi-vehicular fatal involvements tend to be more costly than the single-vehicular fatal involvements. For P.D.O. involvements, the standard errors are quite small. This probably indicates a clustering of observations at relatively low dollar values. If the accident is severe enough to cause much property damage, it is probably severe enough to inflict injuries with the result that high-dollar property damages end up as components in injury and/or fatal involvement costs, Finally, for each accident type, costs per involvement increase as the severity becomes greater.

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[15]As the data base is disaggregated, the usable frequencies for calculating estimates also decline. The following table shows the numbers of frequencies which were used in estimating the involvement costs reported in tabular form in this section:

Data Base Involvement Frequencies,
by Classificatory Category and Vehicle Type, Data-States

| | Vehicle Type | | |
|---|---|---|---|
| | | Truck | |
| Category | Pass. Car | Single Unit | Combination |
| Accident Type - All | 19,021 | 9,195 | 1,653 |
| Accident Type - Rural | 4,868 | 2,514 | 656 |
| Accident Type - Urban | 13,848 | 6,602 | 963 |
| Highway Type | 13,182 | 6,163 | 990 |
| Road Characteristics | 8,734 | 2,062 | 678 |
| Traffic Control - (Intersections) | 3,332 | 1,113 | 370 |
| Highway System | 18,517 | 9,105 | 1,616 |

Table 2 shows average costs of involvements for passenger cars in rural accidents. The costs of rural involvements - $5668 (fatal), $1749 (injury), and $211 (P.D.O.) - are higher than the corresponding costs shown in Table 1. This is, at least partly, a result of higher travelling speeds in rural areas which tend to create more severe and, hence, more costly accidents. Within Table 2, the effect of disaggregation (from "rural and urban" in Table 1 to "rural only" in Table 2) is seen manifested in larger values of the standard error. Some of the increase is due to the smaller number of observations available for "rural only" calculations.

In Table 3, estimates of urban passenger car involvements indicate that the costs of single-vehicle fatal involvements tend to exceed the costs of similar involvements in rural areas (Table 2). In comparing rural and urban injury involvements, there is a sizeable difference between the involvement costs for all accident types ($1749 for rural and $970 for urban). This result is apparently due to the less costly nature of urban multi-vehicular involvements, since rural single-vehicular involvements are not unambiguously more costly than the urban equivalents.

When the data are classified by highway type, the results (Table 4) show that the most costly involvements seem to happen on undivided, two-lane roads. The costs of fatal and injury involvements on divided, four-lane roads, while not the lowest, are considerably below similar involvement costs in the undivided, two-lane category. This difference is partly due to the occurrence of a relatively larger number of high-cost, head-on accidents. The highest cost P.D.O. involvements occur on divided roads of six-or-more lanes.

Table 2

Direct Cost per Involvement, Passenger Cars, by Accident Type and Severity, Rural, Data-States

| Accident Type | Severity | | |
|---|---|---|---|
| | Fatal | Injury | P.D.O. |
| Multi-Vehicle: | | | |
| Head-on | $ 9,578 | $2,703 | $271 |
| Std. Error (S.E.) | $ 2,011 | $ 568 | $ 20 |
| Rear-End | 7,165 | 1,638 | 289 |
| S.E. | 2,078 | 213 | 21 |
| Angle | 6,216 | 1,314 | 183 |
| S.E. | 995 | 171 | 15 |
| Sideswipe | 7,007 | 1,054 | 132 |
| S.E. | 2,803 | 274 | 15 |
| Turning | 6,248 | 1,369 | 309 |
| S.E. | 1,999 | 233 | 30 |
| Parking | - | 772 | 155 |
| S.E. | - | 463 | 264 |
| Other | 10,849 | 1,615 | 111 |
| S.E. | 8,679 | 678 | 17 |
| Single-Vehicle: | | | |
| Pedestrian | 3,854 | 1,407 | 11 |
| S.E. | 540 | 380 | 1 |
| Train | 6,670 | 1,889 | 172 |
| S.E. | 1,401 | 831 | 103 |
| Bicycle | 3,613 | 510 | - |
| S.E. | 759 | 230 | - |
| Animal | - | 2,169 | 312 |
| S.E. | - | 499 | 25 |
| Fixed-Object | 2,559 | 1,714 | 377 |
| S.E. | 307 | 223 | 41 |
| Other Object | - | 1,650 | 93 |
| S.E. | - | 462 | 2 |
| Non-Collison | 3,963 | 1,838 | 226 |
| S.E. | 515 | 136 | 13 |
| ALL | $ 5,668 | $1,749 | $211 |
| S.E. | $ 516 | $ 112 | $ 6 |

Table 3

Direct Cost per Involvement, Passenger Cars, by Accident Type and Severity, Urban, Data-States

| Accident Type | Severity | | |
|---|---|---|---|
| | Fatal | Injury | P.D.O. |
| Multi-Vehilce: | | | |
| Head-on | $6,066 | $ 890 | $204 |
| Std. Error (S.E.) | $1,031 | $ 151 | $ 11 |
| Rear-End | 5,039 | 863 | 141 |
| S.E. | 1,159 | 60 | 4 |
| Angle | 6,684 | 908 | 201 |
| S.E. | 869 | 42 | 5 |
| Sideswipe | 6,793 | 442 | 127 |
| S.E. | 4,415 | 53 | 11 |
| Turning | 3,073 | 743 | 145 |
| S.E. | 1,321 | 65 | 5 |
| Parking | - | 494 | 64 |
| S.E. | - | 99 | 3 |
| Other | 4,266 | 750 | 124 |
| S.E. | 2,193 | 155 | 6 |
| Single-Vehicle: | | | |
| Pedestrian | 5,875 | 1,439 | 32 |
| S.E. | 388 | 216 | 6 |
| Train | 7,065 | 1,820 | 706 |
| S.E. | 1,448 | 912 | 247 |
| Bicycle | 5,121 | 1,040 | 61 |
| S.E. | 999 | 430 | 13 |
| Animal | 3,173 | 1,548 | 268 |
| S.E. | 2,849 | 741 | 85 |
| Fixed-Object | 3,562 | 2,049 | 219 |
| S.E. | 524 | 410 | 19 |
| Other Object | - | 951 | 86 |
| S.E. | - | 141 | 6 |
| Non-Collision | 3,674 | 1,191 | 205 |
| S.E. | 1,653 | 226 | 28 |
| ALL | $5,480 | $ 970 | $150 |
| S.E. | 279 | $ 39 | $ 2 |

Table 4

Direct Cost per Involvement, Passenger Cars, by Highway Type and Severity, Data-States (except Massachusetts)

| Highway Type | Severity | | |
|---|---|---|---|
| | Fatal | Injury | P.D.O |
| One-Way; One-Lane | - | $ 341 | $ 86 |
| Std. Error (S.E.) | - | $ 102 | $ 9 |
| One-Way; Two Lanes | $5,017 | 513 | 122 |
| S.E. | 1,856 | 205 | 21 |
| One-Way; 3+ Lanes | - | 1,770 | 127 |
| S.E. | - | 1,009 | 13 |
| Undivided; Two-Lanes | 5,921 | 1,539 | 177 |
| S.E. | 651 | 77 | 4 |
| Undivided; Three-Lanes | 2,750 | 713 | 114 |
| S.E. | 1,568 | 135 | 16 |
| Undivided; 4+ Lanes | 5,271 | 1,185 | 173 |
| S.E. | 1,002 | 95 | 5 |
| Divided; 4-Lanes | 3,101 | 1,122 | 168 |
| S.E. | 713 | 157 | 12 |
| Divided; 6+ Lanes | $4,638 | $1,601 | $265 |
| S.E. | $2,412 | $ 352 | $ 29 |

With Tables 5 and 6, the effects of disaggregation are more pronounced. The smaller number of observations yield larger standard errors relative to the means; consequently, the reliability of the mean costs estimates is lessened. In Table 5, for fatal involvements at intersections and on straight sections of roads, the costs tend to be higher than for the average fatal involvement (Table 1). The cost of involvements at railroads includes those involvements (from Table 1) of single-vehicles with train as well as any other accident occurring at a crossing whether a train was involved or not.

The data in Table 6 are presented to give a more finely detailed profile of accidents occurring at intersections. Although the size of the standard errors make some comparisons difficult, involvements at intersections controlled by stop-signs seem to be more costly than those involvements occurring at intersections having stop-go lights. Involvements (injury and P.D.O.) at intersections policed by a traffic officer are among the least costly of the categories.

When categorized by highway system, involvement cost data yield an interesting comparison. In Table 7, note that the costs (for all severities) of involvements on Federal-aid primary tend to be the same as those costs for involvements on the non-Federal aid system. Also the costs for involvements on the Federal-aid secondary system are similar to those for involvements occurring on local roads. Finally, the costs in the first combination (Federal-aid primary and non-Federal aid) are higher than the costs in the latter combination (Federal-aid secondary and local roads). Except for the fatal and injury involvements, the relative errors of all the means in Table 7 are less then 10%.

Table 5

Direct Cost per Involvement, Passenger Car, by Road Characteristics and Severity, Data-States (except New Mexico and Utah)

| Road Characteristic | Severity Fatal | Injury | P.D.O. |
|---|---|---|---|
| Intersection | $6,152 | $ 954 | $142 |
| Std. Error (S.E.) | $ 430 | $ 67 | $ 4 |
| Straight* | 6,177 | 1,042 | 112 |
| S.E. | 679 | 115 | 3 |
| Curve* | 5,366 | 1,133 | 130 |
| S.E. | 859 | 204 | 16 |
| Bridge | 3,753 | 963 | 311 |
| S.E. | 1,013 | 154 | 59 |
| Underpass | - | 2,167 | - |
| S.E. | - | 737 | - |
| Interchange | - | 474 | 100 |
| S.E. | - | 431 | 34 |
| Tunnel | - | 227 | - |
| S.E. | - | 32 | - |
| Railroad | $7,418 | $ 768 | $ 78 |
| S.E. | $ 964 | $ 261 | $ 15 |

*To avoid ambiguity, these characteristics were coded at a lower priority than the others. Thus, for example, an involvement occurring at a bridge on a straight road was considered a "bridge" involvement. "Straight" and "curve" were coded when no other characteristic existed at the location.

Table 6

Direct Cost per Intersection Involvement, Passenger Cars, by Type of Traffic Control and Severity, Data-States

| Type of Control | Severity | | |
|---|---|---|---|
| | Fatal | Injury | P.D.O. |
| Stop-Go Light | $ 4794 | $ 953 | $160 |
| Std. Error (S.E.) | $ 767 | $ 67 | $ 5 |
| Officer | 14,579* | 704 | 163 |
| S.E. | 14,121* | 155 | 28 |
| Flashing Light | 7930 | 908 | 181 |
| S.E. | 3172 | 291 | 31 |
| Stop Sign | 6067 | 1126 | 179 |
| S.E. | 728 | 79 | 7 |
| Yield Sign | - | 1067 | 303 |
| S.E. | - | 459 | 55 |
| Warning Sign | 5468 | 1224 | 182 |
| S.E. | 1148 | 306 | 33 |
| Other | 10,960 | 1037 | 227 |
| S.E. | 3178 | 176 | 34 |
| No Control | $ 5466 | $1016 | $187 |
| S.E. | $ 382 | $ 102 | $ 6 |

*These are based on only two involvements - one a very low cost and the other a very high cost involvement.

Table 7

Direct Cost per Involvement, Passenger Cars, by Highway System and Severity, Data-States

| Highway System | Severity | | |
|---|---|---|---|
| | Fatal | Injury | P.D.O. |
| Federal Aid Primary | $6097 | $1364 | $189 |
| Std. Error (S.E.) | $ 549 | $ 82 | $ 4 |
| Federal Aid Secondary | 4982 | 1126 | 183 |
| S.E. | 548 | 90 | 9 |
| Non-Federal Aid | 5990 | 1288 | 173 |
| S.E. | 1198 | 180 | 9 |
| Local Road | $4998 | $ 924 | $142 |
| S.E. | $ 300 | $ 46 | $ 3 |

Trucks: An important feature to be emphasized concerning the truck involvement costs is the relative small-sized samples from which the following estimates have been made (see Footnote 15, above section). This is particularly necessary for the combination-truck involvements where, at the highest level of aggregation, only 1,653 observations are available. The data are presented in tabular form (Tables 8-14) in the same manner as the previous passenger car data. Again, some of the highlights of the data are pointed out, but no attempt has been made to provide an exhaustive explanation of the data.

As might be expected, a general feature of truck involvement costs is that the larger, heavier combination-trucks experience higher involvement costs than do the single-unit trucks. For all types of accidents, Table 8 shows the costs for combination trucks to be greater for each severity than the corresponding costs of single-unit truck involvements. Where a head-on fatal involvement was the most costly for passenger cars, combination-trucks experience their most costly fatal involvements in collisions with fixed-objects and non-collision accidents. This suggests the importance of the loss and/or destruction of cargo as an element in the costs of truck involvements. Additional evidence of the probable importance of cargo loss in truck involvement costs is suggested by the relatively high cost of P.D.O. involvements for combination trucks, particularly when involved in collisions with fixed-objects and non-collision accidents. For single- unit trucks, the costs per involvement for all types of accidents are roughly the same as the corresponding costs for passenger cars (see last row, Table 1), This perhaps reflects the presence of a relatively large number of pick-up trucks in this category.

Table 8

Direct Cost per Involvement, Single-Unit and Combination Trucks, by Accident Type and Severity, Data-States

| Accident Type | Severity by Truck Type | | | | | |
|---|---|---|---|---|---|---|
| | Single-Unit | | | Combination | | |
| | Fatal | Injury | P.D.O. | Fatal | Injury | P.O.D. |
| Multi-Vehicle: | | | | | | |
| Head-On | $ 5897 | $1567 | $ 425 | $ 6705 | $ 5313 | $ 1273 |
| Std. Error (S.E.) | $ 1887 | $ 204 | $ 72 | $ 1542 | $ 1966 | $ 496 |
| Rear-End | 4372 | 561 | 113 | 6076 | 796 | 190 |
| S.E. | 1399 | 58 | 11 | 3281 | 271 | 46 |
| Angle | 7269 | 728 | 164 | 6689 | 1659 | 386 |
| S.E. | 1149 | 55 | 9 | 2876 | 846 | 93 |
| Sideswipe | 3199 | 933 | 101 | - | 477 | 83 |
| S.E. | 2847 | 336 | 11 | - | 143 | 24 |
| Turning | 5068 | 735 | 120 | 3761 | 1818 | 102 |
| S.E. | 1977 | 96 | 7 | 1128 | 1145 | 35 |
| Parking | - | 306 | 66 | - | 665 | 145 |
| S.E. | - | 150 | 16 | - | 638 | 74 |
| Other | 1017 | 751 | 111 | 1134 | 239 | 384 |
| S.E. | 417 | 188 | 18 | 703 | 124 | 200 |
| Single-Vehicle: | | | | | | |
| Pedestrian | 4685 | 1370 | - | 4615 | 1625 | - |
| S.E. | 571 | 219 | - | 1154 | 358 | - |
| Train | 12,524 | 3017 | 1206 | - | 8056 | 1670 |
| S.E. | 3342 | 1177 | 482 | - | 2256 | 685 |
| Bicycle | 3978 | 761 | 41 | 3000 | 285 | - |
| S.E. | 1273 | 297 | 11 | 897 | 121 | - |
| Animal | 1738 | 2018 | 348 | - | 6891 | 1529 |
| S.E. | 1234 | 747 | 45 | - | 5651 | 902 |
| Fixed-Object | 7469 | 1908 | 545 | 15,706 | 7671 | 2198 |
| S.E. | 1568 | 248 | 55 | 5497 | 3989 | 769 |
| Other Object | - | 752 | 75 | - | 311 | 105 |
| S.E. | - | 271 | 15 | - | 146 | 22 |
| Non-Collision | 3310 | 2212 | 847 | 12,184 | 6488 | 2924 |
| S.E. | 596 | 288 | 93 | 2071 | 1038 | 673 |
| All | $ 5274 | $ 951 | $ 193 | $ 6698 | $ 2073 | $695 |
| S.E. | $ 411 | $ 43 | $ 8 | $ 918 | $ 332 | $ 97 |

The data in Tables 9 and 10 show that for all types of truck involvements, those in rural areas tend to be more costly than those in urban areas. This is true particularly for combination truck involvements. As with passenger cars, the costs for truck involvements tend to increase with the severity of the accident, the notable exceptions being combination trucks involved in rural, fixed-object accidents (Table 9) and in urban, head-on accidents (Table 10).

The primary feature of the data in Table 11 is the comparison of the costs of involvements occurring on two of the most common types of highways - undivided, two-lanes and divided, four-lanes. For each type of truck and for all severities, involvements on undivided, two-lane roads are more costly than involvements which occur on divided, four-lane roads. In fact, except for the costs of fatal involvements on undivided roads with four or more lanes, the undivided, two-lane roads generate the most costly involvements when all highway types are considered.

When truck involvement costs are calculated with respect to road characteristics, the standard errors of the mean estimates become relatively large due to two factors: (1) the reduction in the number of observations caused by the "sifting-out" process of cross-classification (disaggregation); and (2) the absence of these data from two of the data-states. In fact, the relative error is less than ten percent in only one of the cells in Table 12--single-unit trucks involved in intersection accidents which yield only property damage. For Table 13, all the data-states contributed observations, but restriction to intersection involvements reduces the size of the sample (see footnote 15, p. 25).

Table 9

Direct Cost per Involvement, Single-Unit and Combination Trucks, by Accident Type and Severity, Rural, Data-States

| Accident | Severity by Truck Type | | | | | |
|---|---|---|---|---|---|---|
| | Single-Unit | | | Combination | | |
| | Fatal | Injury | P.D.O. | Fatal | Injury | P.O.D. |
| Multi-Vehicle: | | | | | | |
| Head-On | $ 6,296 | $ 1,824 | $ 561 | $ 7,351 | $ 4,728 | $ 1,498 |
| Std. Error (S.E.) | $ 2,078 | $ 255 | $ 112 | $ 1,764 | $ 1,466 | $ 659 |
| Rear-End | 4,937 | 1,180 | 208 | 6,831 | 1,343 | 404 |
| S.E. | 1,728 | 212 | 52 | 3,620 | 686 | 129 |
| Angle | 8,619 | 1,127 | 189 | 8,771 | 4,185 | 977 |
| S.E. | 1,724 | 169 | 18 | 3,947 | 2,595 | 303 |
| Sideswipe | 4,333 | 1,276 | 200 | - | 649 | 150 |
| S.E. | 3,987 | 561 | 40 | - | 266 | 55 |
| Turning | 6,362 | 1,121 | 193 | 4,137 | 1,620 | 167 |
| S.E. | 2,481 | 179 | 18 | 1,514 | 583 | 87 |
| Parking | - | - | 155 | - | - | - |
| S.E. | - | - | 68 | - | - | - |
| Other | 1,758 | 1,697 | 324 | 1,134 | 187 | 1,250 |
| S.E. | 781 | 543 | 78 | 703 | 140 | 650 |
| Single-Vehicle: | | | | | | |
| Pedestrian | 2,107 | 833 | - | 5,503 | - | - |
| S.E. | 1,075 | 238 | - | 2,256 | - | - |
| Train | 16,987 | 4,558 | 1,809 | - | - | - |
| S.E. | 1,206 | 2,188 | 868 | - | - | - |
| Bicycle | 2,805 | 1,771 | - | - | - | - |
| S.E. | 982 | 1,008 | - | - | - | - |
| Animal | 1,738 | 2,018 | 368 | - | 6,891 | 1,529 |
| S.E. | 1,234 | 747 | 52 | - | 5,651 | 902 |
| Fixed-Object | 6,359 | 2,164 | 650 | 15,706 | 1,873 | 4,770 |
| S.E. | 1,781 | 325 | 85 | 5,466 | 1,236 | 2,099 |
| Other-Object | - | 900 | 82 | - | - | 67 |
| S.E. | - | 347 | 10 | - | - | 24 |
| Non-Collision | 3,325 | 2,538 | 941 | 10,175 | 7,089 | 3,215 |
| S.E. | 632 | 330 | 113 | 2,646 | 1,134 | 781 |
| All | $ 5,406 | $1,632 | $ 405 | $ 7,632 | $ 3,314 | $ 1,493 |
| S.E. | $ 573 | $ 101 | $ 28 | $ 1,206 | $ 683 | $ 237 |

Table 10

Direct Cost per Involvement, Single-Unit and Combination Trucks, by Accident Type and Severity, Urban, Data-States

| Accident | Severity by Truck Type | | | | | |
|---|---|---|---|---|---|---|
| | Single-Unit | | | Combination | | |
| | Fatal | Injury | P.D.O. | Fatal | Injury | P.O.D. |
| Multi-Vehicle: | | | | | | |
| Head-On | $ 2,038 | $ 960 | $ 179 | $ 3,480 | $ 5,938 | $ 660 |
| Std. Error (S.E.) | $ 1,039 | $ 346 | $ 21 | $ 1,044 | $ 3,860 | $ 416 |
| Rear-End | 2,306 | 412 | 92 | - | 481 | 88 |
| S.E. | 1,176 | 49 | 7 | - | 139 | 29 |
| Angle | 5,042 | 654 | 160 | 1,482 | 487 | 192 |
| S.E. | 1,109 | 57 | 10 | 667 | 122 | 63 |
| Sideswipe* | 366 | 773 | 68 | - | 347 | 47 |
| S.E. | 190 | 425 | 6 | - | 153 | 23 |
| Turning | 1,185 | 470 | 99 | 2,759 | 1,895 | 88 |
| S.E. | 687 | 63 | 8 | 1,264 | 1,573 | 38 |
| Parking | - | 320 | 61 | - | 665 | 16 |
| S.E. | - | 157 | 16 | - | 632 | 8 |
| Other | 424 | 395 | 87 | - | 260 | 21 |
| S.E. | 229 | 142 | 17 | - | 164 | - |
| Single-Vehicle: | | | | | | |
| Predestrian | 5,545 | 1,410 | - | 3,854 | 1,475 | - |
| S.E. | 627 | 234 | - | 1,156 | 531 | - |
| Train | 9,848 | 1,476 | 605 | - | 8,056 | 1,670 |
| S.E. | 5,515 | 457 | 224 | - | 2,256 | 685 |
| Bicycle | 5,348 | 638 | 38 | 3,004 | 293 | - |
| S.E. | 2,567 | 306 | 8 | 901 | 148 | - |
| Animal | - | - | 180 | - | - | - |
| S.E. | - | - | 86 | - | - | - |
| Fixed-Object | 10,982 | 1,423 | 456 | - | 1,622 | 966 |
| S.E. | 2,921 | 356 | 73 | - | 713 | 396 |
| Other Object | - | - | 66 | - | 215 | 145 |
| S.E. | - | - | 32 | - | 189 | 35 |
| Non-Collision | 3,148 | 1,013 | 465 | 16,872 | 1,266 | 1,651 |
| S.E. | 1,262 | 63 | 18 | 3,872 | 354 | 299 |
| All | $5,040 | $ 670 | $ 123 | $ 4,343 | $ 1,131 | $ 207 |
| S.E. | $ 514 | $ 42 | $ 5 | $ 970 | $ 311 | $ 37 |

*The reversal of the relative magnitudes of fatal and injury costs is probably due to the lack of adequate sample data for this category.

Table 11

Direct Cost Per Involvement, Single-Unit and Combination Trucks, by Highway Type and Severity, Data-States (except Massachusetts)

| | Severity by Truck Type | | | | | |
|---|---|---|---|---|---|---|
| | Single-Unit | | | Combination | | |
| Highway Type | Fatal | Injury | P.D.O. | Fatal | Injury | P.D.O. |
| One-Way; One-Lane | - | $ 643 | $ 201 | - | - | - |
| Std. Error (S.E.) | | $ 469 | $ 139 | | | |
| One-Way; Two-Lanes | - | 147 | 54 | - | - | - |
| S.E. | | 107 | 44 | | | |
| One-Way; 3+ Lanes | - | 300 | 79 | - | - | 27 |
| S.E. | | 76 | 16 | | | 16 |
| Undivided; Two-Lanes | 4,512 | 1,473 | 285 | 6,378 | 4,962 | 1,192 |
| S.E. | 586 | 10 | 17 | 1,212 | 1,091 | 179 |
| Undivided; Three-Lanes | 1,650 | 311 | 74 | - | - | - |
| S.E. | 594 | 255 | 36 | | | |
| Undivided; 4+ Lanes | 1,547 | 698 | 126 | 7,781 | 1,187 | 730 |
| S.E. | 464 | 112 | 8 | 4,046 | 309 | 321 |
| Divided; Four-Lanes | 4,406 | 855 | 137 | 3,834 | 4,167 | 330 |
| S.E. | 2,379 | 197 | 14 | 2,760 | 2,209 | 162 |
| Divided; 6+ Lanes | 2,477 | 25 | 144 | - | 63 | - |
| S.E. | 1,908 | 15 | 56 | | 37 | |

Table 12

Direct Cost Per Involvement, Single-Unit and Combination Trucks, By Road Characteristics and Severity, Data-States (except New Mexico and Utah)

| Road Characteristic | Severity by Truck Type | | | | | |
|---|---|---|---|---|---|---|
| | Single-Unit | | | Combination | | |
| | Fatal | Injury | P.D.O. | Fatal | Injury | P.D.O. |
| Intersection | $ 6,738 | $ 742 | $ 98 | $ 4,822 | $ 725 | $ 131 |
| Std. Error (S.E.) | $ 1,213 | $ 82 | $ 10 | $ 1,254 | $ 138 | $ 34 |
| Straight* | 5,505 | 978 | 123 | 7,510 | 2,455 | 275 |
| S.E. | 1,156 | 147 | 16 | 2,629 | 859 | 94 |
| Curve* | 4,868 | 1,191 | 231 | 6,547 | 2,558 | 568 |
| S.E. | 2,239 | 345 | 72 | 1,505 | 1,458 | 261 |
| Bridge | 4,040 | 1,006 | 182 | 18,949 | 14,695 | 4,508 |
| S.E. | 2,748 | 362 | 56 | 7,390 | 8,082 | 4,192 |
| Railroad | 11,140 | 2,448 | 610 | - | 4,515 | 92 |
| S.E. | 3,453 | 1,020 | 409 | | 2,077 | 54 |
| Underpass | - | - | - | - | - | 466 |
| S.E. | | | | | | 219 |
| Interchange | - | - | - | - | - | - |
| S.E. | | | | | | |
| Tunnel | - | - | - | - | - | - |
| S.E. | | | | | | |

* To avoid ambiguity, these characteristics were coded at a lower priority than the others. Thus, for example, an involvement occurring at a bridge on a straight road was considered a "bridge" involvement. "Straight" and "curve" were coded when no other characteristic existed at the location.

Table 13

Direct Cost per Intersection Involvement, Single-Unit and Combination Trucks, by Type of Traffic Control and Severity, Data-States

| Type of Control | Severity | | | | | |
|---|---|---|---|---|---|---|
| | Single-Unit | | | Combination | | |
| | Fatal | Injury | P.D.O. | Fatal | Injury | P.D.O. |
| Stop-Go Light | $ 5,748 | $ 536 | $ 92 | $ 2,086 | $ 676 | $139 |
| Std. Error (S.E.) | $ 1,437 | $ 54 | $ 6 | $ 647 | $ 176 | $ 33 |
| Officer | 14,613 | 836 | 139 | 12,481 | 1,152 | 564 |
| S.E. | 10,667 | 251 | 17 | 10,484 | 806 | 288 |
| Flashing Light | 11,356 | 445 | 79 | - | 2,339 | 174 |
| S.E. | 1,140 | 111 | 13 | - | 1,403 | 111 |
| Stop Sign | 6,774 | 990 | 201 | 6,191 | 2,684 | 129 |
| S.E. | 156 | 129 | 22 | 1,795 | 1,798 | 43 |
| Yield Sign | - | 1,850 | - | - | - | - |
| S.E. | | 11 | | | | |
| Warning Sign | 3,050 | 837 | 148 | - | 1,600 | 113 |
| S.E. | 1,952 | 184 | 15 | - | 688 | 57 |
| Other | - | 3,495 | 237 | - | - | 618 |
| S.E. | - | 1,503 | 97 | - | - | 587 |
| No Control | 5,607 | 872 | 175 | 6,197 | 672 | 474 |
| S.E. | 1,458 | 148 | 16 | 3,160 | 269 | 213 |

Table 14

Direct Cost Per Involvement, Single-Unit and Combination Trucks, By Highway System and Severity, Data-States

| | Severity by Truck Type | | | | | |
|---|---|---|---|---|---|---|
| | Single-Unit | | | Combination | | |
| Highway System | Fatal | Injury | P.D.O. | Fatal | Injury | P.D.O. |
| Federal Aid Primary | $ 4,857 | $ 1,184 | $ 246 | $ 6,194 | $ 2,917 | $ 959 |
| Std. Error (S.E.) | $ 631 | $ 71 | $ 15 | $ 1,053 | $ 583 | $ 153 |
| Federal Aid Secondary | 4,776 | 1,327 | 208 | 8,079 | 1,508 | 894 |
| S.E. | 1,337 | 12 | 19 | 5,090 | 729 | 384 |
| Non-Federal Aid | 7,513 | 922 | 103 | 2,186 | 830 | 354 |
| S.E. | 1,728 | 203 | 22 | 700 | 274 | 181 |
| Local Road | 6,025 | 643 | 119 | 9,212 | 569 | 163 |
| S.E. | 663 | 58 | 7 | 2,119 | 137 | 41 |

Classified by highway system, average costs for truck involvements are given in Table 14. Unlike the similar data for passenger cars, the mean costs of truck involvements do not seem to vary systematically with respect to the highway system classification.

### Texas Involvement Frequencies

The data in Appendix D are the frequencies of reported involvements in Texas during 1969. The data have been classified to conform to the categories established by the data-states. The data are presented in the following order: (1) passenger cars (Tables D1-D5); (2) single-unit trucks (Table D6-D10); and (3) combination trucks (Tables D11-D15).

Involvement frequencies are used as inputs in determining accident costs, and will not be discussed at this point. They are presented in detailed tabular form, however, in the event that readers of this study might have select purposes for which involvement frequencies could be used.

### Value of the Loss of Future Earnings

As mentioned previously, the direct cost components of accident costs largely are representative of "out of pocket" expenses incurred. One of the direct costs which is not "out of pocket," however, is the measure of income lost due to occurrence of injuries which cause loss of work time.

An extension of this measure of loss of earnings can be made to include the present value of expected future incomes for those persons fatally injured in accidents. The inclusion of this loss of future earnings leads, naturally, to higher costs for fatal accidents. However, since the measure does not purport to quantify the "value of life" (which certainly would be higher than the present value of expected future earnings), the resulting estimates are not considered to be "too high."

The data in Table 15 are the basis for the weighted averages (by age and sex) of the value of expected future earnings for persons killed in Texas in 1969. Two discount rates, 10% (Cols. 2 and 6) and 4% (Cols. 3 and 7) are used in making the estimates which follow. Further, the negative values which exist in the late years are the result of using a "net" rather than a "gross" earnings concept. In computing the average loss of future earnings, the present study does not include the negative amounts obtained by Weisbrod and arbitrarily assigns a value of zero for those ages for which discounted future earnings are negative.[1]

The results of averaging the data in Table 15 are shown in Table 16. Rows 1 and 2 of Table 15 are weighted by the age composition of the fatalities in the respective sexes. Row 3 is weighted further by the sex composition of the total number of fatalities.

Utilizing the cost estimates developed in this chapter, the task of the next chapter is to derive cost estimates for selected types of accidents.

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[1]This procedure was used also in the Washington Area Study when negative values were obtained. See Washington Area Study, p. 210.

Table 15

Present Values of Net Future Earnings per Person, by Age and Sex (at 4 and 10 Percent Discount Rates), and Number of Persons Killed in Texas in Motor Vehicle Traffic Accidents in 1969

| Males | | | | Females | | |
|---|---|---|---|---|---|---|
| Number Killed (1) | 10% Discount (2) | 4% Discount (3) | Age (4) | Number Killed (5) | 10% Discount (6) | 4% Discount (7) |
| 1 | $ -635 | $ -672 | 100 | - | $ -635 | $ -672 |
| - | -1,155 | -1,292 | 97 | 1 | -1,155 | -1,292 |
| - | -1,576 | -1,865 | 92 | 2 | -1,576 | -1,865 |
| 21 | -1,911 | -2,391 | 87 | 6 | -1,911 | -2,391 |
| 38 | -2,368 | -3,314 | 82 | 20 | -2,368 | -3,314 |
| 51 | -2,610 | -4,083 | 77 | 19 | -2,610 | -4,083 |
| 13 | -2,812 | -4,378 | 74 | 16 | -2,868 | -4,841 |
| 17 | -2,926 | -4,560 | 73 | 10 | -2,867 | -4,917 |
| 13 | -2,923 | -4,647 | 72 | 8 | -2,710 | -4,820 |
| 13 | -2,747 | -4,536 | 71 | 16 | -2,440 | -4,590 |
| 20 | -2,289 | -4,119 | 70 | 13 | -2,116 | -4,289 |
| 17 | -1,491 | -3,323 | 69 | 8 | -1,620 | -3,792 |
| 26 | -391 | -2,173 | 68 | 9 | -936 | -3,073 |
| 16 | 936 | -736 | 67 | 12 | -94 | -2,160 |
| 16 | 2,408 | 913 | 66 | 8 | 836 | -1,114 |
| 25 | 3,988 | 2,742 | 65 | 7 | 1,839 | 52 |
| 21 | 5,594 | 4,663 | 64 | 13 | 2,853 | 1,272 |
| 27 | 7,244 | 6,697 | 63 | 12 | 3,912 | 2,582 |
| 21 | 8,866 | 8,769 | 62 | 13 | 4,980 | 3,949 |
| 24 | 10,450 | 10,860 | 61 | 21 | 6,079 | 5,387 |
| 24 | 12,005 | 12,982 | 60 | 17 | 7,209 | 6,902 |
| 26 | 13,844 | 15,077 | 59 | 13 | 8,354 | 8,476 |
| 18 | 14,898 | 17,153 | 58 | 9 | 9,523 | 10,114 |
| 22 | 16,212 | 19,199 | 57 | 19 | 10,713 | 11,821 |

Present Values of Net Future Earnings per Person, by Age and Sex (at 4 and 10 Percent Discount Rates), and Number of Persons Killed in Texas in Motor Vehicle Traffic Accidents in 1969

| Males | | | | Females | | |
|---|---|---|---|---|---|---|
| Number Killed (1) | 10% Discount (2) | 4% Discount (3) | Age (4) | Number Killed (5) | 10% Discount (6) | 4% Discount (7) |
| 27 | $17,486 | $21,186 | 56 | 13 | $11,885 | $13,548 |
| 30 | 18,737 | 23,216 | 55 | 11 | 13,026 | 15,285 |
| 37 | 19,973 | 25,255 | 54 | 15 | 14,130 | 17,019 |
| 25 | 21,210 | 27,337 | 53 | 13 | 15,226 | 18,780 |
| 29 | 22,406 | 29,401 | 52 | 9 | 16,311 | 20,560 |
| 36 | 23,624 | 31,523 | 51 | 14 | 17,369 | 22,344 |
| 34 | 24,861 | 33,695 | 50 | 11 | 32,057 | 24,148 |
| 39 | 26,162 | 35,963 | 49 | 20 | 19,524 | 26,035 |
| 29 | 27,533 | 38,336 | 48 | 8 | 20,731 | 28,056 |
| 29 | 28,965 | 40,809 | 47 | 7 | 21,994 | 30,170 |
| 34 | 30,373 | 43,296 | 46 | 16 | 23,291 | 32,353 |
| 28 | 31,732 | 45,769 | 45 | 9 | 24,560 | 34,545 |
| 28 | 33,024 | 48,207 | 44 | 14 | 25,798 | 36,740 |
| 28 | 34,240 | 50,596 | 43 | 10 | 26,977 | 38,902 |
| 30 | 35,375 | 52,928 | 42 | 10 | 28,088 | 41,026 |
| 32 | 36,478 | 55,244 | 41 | 15 | 29,125 | 43,097 |
| 27 | 37,508 | 57,502 | 40 | 12 | 30,090 | 45,108 |
| 33 | 38,447 | 59,675 | 39 | 13 | 30,981 | 47,058 |
| 28 | 39,287 | 61,758 | 38 | 9 | 31,779 | 48,921 |
| 26 | 40,012 | 63,720 | 37 | 13 | 32,472 | 50,683 |
| 24 | 40,567 | 65,504 | 36 | 8 | 33,010 | 52,279 |
| 33 | 40,821 | 66,962 | 35 | 10 | 33,241 | 53,548 |
| 20 | 40,955 | 68,266 | 34 | 8 | 33,332 | 54,649 |
| 34 | 41,008 | 69,452 | 33 | 19 | 33,326 | 55,615 |
| 25 | 40,988 | 70,522 | 32 | 6 | 33,271 | 56,497 |
| 29 | 40,910 | 71,489 | 31 | 6 | 33,200 | 57,321 |
| 28 | 40,768 | 72,357 | 30 | 9 | 33,107 | 58,090 |
| 36 | 40,567 | 73,110 | 29 | 11 | 32,989 | 58,789 |
| 30 | 40,265 | 73,711 | 28 | 13 | 32,840 | 59,424 |

Present Values of Net Future Earnings per Person, by Age and Sex (at 4 and 10 Percent Discount Rates), and Number of Persons Killed in Texas in Motor Vehicle Traffic Accidents in 1969

| Males | | | | Females | | |
|---|---|---|---|---|---|---|
| Number Killed (1) | 10% Discount (2) | 4% Discount (3) | Age (4) | Number Killed (5) | 10% Discount (6) | 4% Discount (7) |
| 32 | 39,912 | 74,216 | 27 | 11 | 32,703 | 60,034 |
| 37 | 39,348 | 74,433 | 26 | 8 | 32,604 | 60,646 |
| 49 | 38,491 | 74,296 | 25 | 19 | 32,537 | 61,261 |
| 55 | 37,296 | 73,731 | 24 | 15 | 32,429 | 61,802 |
| 58 | 35,807 | 72,776 | 23 | 17 | 32,242 | 62,232 |
| 79 | 34,071 | 71,466 | 22 | 18 | 31,868 | 62,437 |
| 72 | 32,125 | 69,828 | 21 | 23 | 31,204 | 62,297 |
| 91 | 30,000 | 67,898 | 20 | 27 | 29,733 | 61,274 |
| 96 | 27,742 | 65,694 | 19 | 20 | 27,892 | 59,772 |
| 108 | 25,267 | 63,153 | 18 | 35 | 25,728 | 57,828 |
| 87 | 22,789 | 60,406 | 17 | 27 | 23,279 | 55,460 |
| 73 | 20,180 | 57,550 | 16 | 25 | 20,636 | 52,761 |
| 54 | 17,684 | 54,612 | 15 | 21 | 18,061 | 49,990 |
| 42 | 15,388 | 51,768 | 14 | 19 | 15,724 | 47,336 |
| 22 | 13,356 | 49,094 | 13 | 15 | 13,665 | 44,849 |
| 17 | 11,569 | 46,590 | 12 | 12 | 11,853 | 42,525 |
| 13 | 10,000 | 44,244 | 11 | 10 | 10,265 | 40,350 |
| 17 | 8,640 | 42,054 | 10 | 8 | 8,878 | 38,319 |
| 11 | 7,451 | 40,000 | 9 | 7 | 7,670 | 36,421 |
| 10 | 6,422 | 38,074 | 8 | 5 | 6,621 | 34,641 |
| 15 | 5,522 | 36,263 | 7 | 8 | 5,705 | 32,970 |
| 15 | 4,733 | 34,548 | 6 | 11 | 4,900 | 31,391 |
| 19 | 4,039 | 32,919 | 5 | 15 | 4,191 | 29,892 |
| 13 | 3,429 | 31,374 | 4 | 17 | 3,567 | 28,473 |
| 19 | 2,890 | 29,900 | 3 | 14 | 3,016 | 27,118 |
| 11 | 2,414 | 28,491 | 2 | 12 | 2,528 | 25,828 |
| 14 | 1,994 | 26,580 | 1 | 11 | 2,098 | 24,578 |
| 22 | 1,569 | 25,021 | 0 | 26 | 1,672 | 22,827 |

Source: Cols. 2, 3, 6 and 7 are data based on Weisbrod, _op. cit._, pp. 60-61. Weisbrod's estimates have been adjusted by the ratio of the 1969 CPI: 1950 CPI. Cols. 1 and 5 are tabulated from Texas Department of Public Safety, _Motor Vehicle Traffic Accidents 1969_, p. 12.

Table 16

Weighted Averages of Present Values of Net Future Earnings, Discounted at 4% and 10%, Persons Killed in Texas Accidents, 1969

(rounded to nearest hundred dollars)

| Persons Killed | Present Value - 10% | Present Value - 4% |
|---|---|---|
| (1) Male | $23,200 | $45,200 |
| (2) Female | 16,900 | 33,300 |
| (3) All | 21,300 | 41,600 |

## ACCIDENTS AND ACCIDENT COSTS

Utilizing the involvement cost data developed in the previous sections, a set of accident cost estimates can be derived for selected accident categories. Limitations of involvement cost data restrict the discussion of accident costs to three types of vehicle combinations: passenger cars only (single and multi-vehicular accidents), trucks only (single and multi-vehicular accidents), and car-truck multi-vehicular accidents.

The development of these accident cost estimates is, briefly, the result of combining the direct and indirect involvement costs into a weighted average cost - the weights having been determined from the accident experience in Texas in 1969. The procedures used to develop the data in Tables 17-28 are discussed below.

Truck accidents: Since truck involvement and involvement cost data are available for single-unit and combination trucks, the direct cost estimates for all truck involvements are weighted averages of the direct costs of single-unit and combination-truck involvements. The weights used in deriving these weighted averages are based on the relative proportions of the two types of trucks involved in accidents in Texas. Thus, for example, the direct cost of a truck/pedestrian fatal accident would be the sum of the cost of a single-unit truck/pedestrian involvement multiplied by the percentage that single-unit involvements are of total truck involvements and the cost of a combination-truck/pedestrian involvement multiplied by the percentage that combination-truck involvements are of total truck involvements.

In the case of single-vehicle accidents, there is no difference between involvement costs and accident costs. For multi-vehicular accidents, the estimated accident costs are some multiple of the involvement costs. In the case of truck only accidents, it is assumed that two trucks are involved per multi-vehicular accident. This assumption gives a downward bias to the estimates of this kind of accident since some truck accidents undoubtedly involve more than two trucks. However, in the absence of the precise data, the assumption of two trucks per multi-vehicular truck accident is used.[1]

Passenger Car Accidents: As in the case of trucks, a single-vehicle passenger car accident is equivalent to an involvement. Thus, accident costs for single-car accidents are the same as the involvement costs. For multi-vehicular accidents involving passenger cars, costs are determined by: (1) assuming the involvement of one passenger car per car/truck and car/other accidents; (2) subtracting from total passenger car involvements (of a given severity, accident type, and rural-urban) the number of cars involved in car/truck and car/other accidents; and (3) dividing the residual determined in (2) by the number of passenger car only accidents (by accident type) to determine the average number of passenger cars involved in the respective types of multi-vehicular

[1] A comparison of the involvement and accident frequencies for trucks suggests this to be a plausible assumption.

accidents. For example, there were 731 passenger cars involved in fatal, head-on accidents. There were 176 car/truck, 10 car/other, and 258 car-only fatal, head-on accidents. Assuming one car involved per car/truck and car/other accidents, there were 545 cars involved in the 258 car-only accidents. This results in an average of 2.11 cars per fatal, head-on accident .

The accident costs for the car-only accidents, then, are obtained by multiplying the average number of cars involved in accidents (of given severity, accident type, rural and/or urban) by the costs per car involvement in those accidents.

Car/Truck Accidents: The accident cost of a car/truck accident is the sum of the cost per truck involvement and cost per car involvement, since it is assumed that only one car and one truck are involved. As is the case of truck-only, multi-vehicular accidents, this assumption gives a downward bias to the cost per car/truck accident since there probably are some of these accidents involving two or more cars or trucks.

Since no appropriate involvement cost estimates were available from the data-states, no accident cost estimates have been derived for those accidents (2% of all Texas accidents) involving vehicles other than cars-only, trucks-only, and cars-trucks. But, frequency data for all vehicular accidents are presented in the Texas accident frequency tables in Appendix E.

In computing weighted averages for accident costs including loss of future earnings (Tables 26-28), the following assumptions are used: (1) in pedestrian and bicycle fatal accidents, only one fatality occurs per accident; and (2) for all other accident type, the number of fatalities which occur per accident are 1.15 in urban accidents, 1.31 in rural accidents, and 1.26 in all accidents.[1]

In presenting the accident cost data, some of the highlights and more general comparisons are mentioned. The direct costs per fatal accident are presented in Tables 17-19. For all accidents, Table 17 shows that head-on accidents are the most costly while collisions with animals yield the least costly accidents. Multi-vehicular accidents involving passenger cars only are more costly than either car/truck or truck-only multi-vehicular accidents. Single-vehicular accidents involving trains are the most costly type of single-vehicle accidents.

Tables 18 and 19 present the direct costs of fatal accidents further classified by rural (Table 18) and urban Table 19 location. In general, rural, multi-vehicular accidents have higher costs than multi-vehicle accidents occurring in urban areas. Just the opposite is the case, however, for single-vehicle accidents where those in urban areas are more costly than similar accidents in rural areas. For all accidents of all vehicle type combinations, those with higher costs occur in rural areas.

For injury accidents, the data in Table 20 indicate that head-on and parking accidents are the most and least costly types of multi-vehicular accidents, respectively. In regard to vehicle-type combination, multi-vehicular accidents involving only passenger cars produce higher costs than either car/truck or multi-truck accidents. In comparing injury accident costs between urban and rural locations, the data in Tables 21 and 22 show that for multi-vehicular accidents of all types

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[1] These averages are obtained by pro-rating the fatality data in Texas Department of Public Safety, _op_. _cit_., p. 7, having allowed for the occurrence of one fatality per pedestrian and bicycle accident.

Table 17

Direct Cost Per Fatal Accident by
Accident Type and Vehicle-Type Combination, Texas, 1969

| Accident Type | Vehicle-Type Combination | | | |
|---|---|---|---|---|
| | Car | Car-Truck | Truck | All |
| Multi-Vehicle | | | | |
| Head-On | $18,152 | $14,809 | $12,432 | $16,516 |
| Rear End | 14,229 | 11,516 | 10,068 | 12,093 |
| Angle | 13,219 | 13,591 | 14,172 | 13,413 |
| Sideswipe | 14,760 | 10,145 | 6,398 | 12,799 |
| Turning | 10,584 | 9,891 | 9,318 | 10,242 |
| Parking | - | - | - | - |
| Other | 7,731 | - | 2,104 | 6,392 |
| All Multi-Vehicle | $14,635 | $13,198 | $10,775 | $13,781 |
| Single-Vehicle | | | | |
| Pedestrian | $ 5,395 | | $ 4,674 | $ 5,279 |
| Train | 6,846 | | 12,524 | 8,119 |
| Bicycle | 4,518 | | 3,000 | 4,281 |
| Animal | 3,173 | | 1,738 | 2,446 |
| Fixed Object | 3,057 | | 8,842 | 4,108 |
| Other Object | 5,578 | | - | - |
| Non-Collision | 3,909 | | 5,402 | 4,283 |
| All | $ 7,780 | $13,198 | $ 7,478 | $ 8,627 |

Table 18

Direct Cost per Fatal Accident, by Accident Type and Vehicle Type Combination, Rural, Texas, 1969

| Accident Type | Vehicle Type Combination | | | |
|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | All |
| Multi-Vehicle | | | | |
| Head-On | $20,163 | $16,315 | $13,474 | $18,119 |
| Rear End | 15,404 | 12,831 | 11,332 | 13,152 |
| Angle | 12,545 | 14,879 | 17,326 | 14,710 |
| Sideswipe | 14,792 | 11,340 | 8,666 | 13,116 |
| Turning | 12,800 | 11,934 | 11,372 | 12,392 |
| Parking | - | - | - | - |
| Other | 10,849 | - | 3,204 | 8,665 |
| All Multi-Vehicle | $17,034 | $14,898 | $12,292 | $15,672 |
| Single-Vehicle | | | | |
| Pedestrian | $3,854 | | $3,239 | $3,758 |
| Train | 6,670 | | 16,987 | 10,109 |
| Bicycle | 3,613 | | 2,805 | 3,371 |
| Animal | - | | 1,738 | 1,738 |
| Fixed Object | 2,559 | | 7,855 | 3,807 |
| Other Object | 5,578 | | - | - |
| Non-Collision | $3,963 | | $4,785 | $4,177 |
| ALL | $8,030 | $14,898 | $7,903 | $9,236 |

Table 19

Direct Cost per Fatal Accident by Accident Type and Vehicle Type Combination, Urban, Texas, 1969

| Accident Type | Vehicle Type Combination | | | |
|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | All |
| Multi-Vehicle | | | | |
| Head-On | $12,899 | $8,559 | $4,986 | $11,204 |
| Rear End | 11,277 | 7,345 | 4,612 | 8,500 |
| Angle | 13,611 | 10,537 | 7,710 | 12,284 |
| Sideswipe | 14,556 | 7,159 | 732 | 12,197 |
| Turning | 6,146 | 4,769 | 3,392 | 5,530 |
| Parking | - | - | - | - |
| Other | 4,266 | - | 808 | 3,371 |
| All Multi-Vehicle | $11,704 | $8,643 | $5,025 | $10,280 |
| Single-Vehicle | | | | |
| Pedestrian | $5,875 | | $5,339 | $5,788 |
| Train | 7,065 | | 9,848 | 7,590 |
| Bicycle | 5,121 | | 5,348 | 5,142 |
| Animal | 3,173 | | - | 3,173 |
| Fixed Object | 3,562 | | 10,982 | 4,615 |
| Other Object | - | | - | - |
| Non-Collision | $3,674 | | $7,070 | $4,441 |
| ALL | $7,155 | $8,643 | $7,162 | $7,363 |

Table 20

Direct Cost per Injury Accident by Accident Type and Vehicle Type Combination, Texas, 1969

| Accident Type | Vehicle-Type Combination | | | |
|---|---|---|---|---|
| | Car | Car-Truck | Truck | All |
| Multi-Vehicle | | | | |
| Head-On | $3,091 | $3,744 | $4,452 | $3.341 |
| Rear End | 2,071 | 1,596 | 1,192 | 1,932 |
| Angle | 1,915 | 1,759 | 1,618 | 1,873 |
| Sideswipe | 1,227 | 1,398 | 1,608 | 1,302 |
| Turning | 1,901 | 1,821 | 1,752 | 1,875 |
| Parking | 967 | 828 | 668 | 923 |
| Other | 1,755 | 1,137 | 1,428 | 1,722 |
| All Multi-Vehicle | $1,994 | $1,856 | $1,745 | $1,955 |
| Single-Vehicle | | | | |
| Pedestrian | $1,441 | | $1,381 | $1,433 |
| Train | 1,834 | | 4,127 | 2,242 |
| Bicycle | 1,006 | | 755 | 974 |
| Animal | 1,878 | | 2,684 | 2,031 |
| Fixed-Object | 1,934 | | 1,948 | 1,942 |
| Other-Object | 1,139 | | 215 | 1,072 |
| Non-Collision | 1,681 | | 2,952 | 1,839 |
| ALL | $1,879 | $1,856 | $2,393 | $1,917 |

Table 21

Direct Cost per Injury Accident, by Accident Type and Vehicle Type Combination, Rural, Texas, 1969

| Accident Type | Vehicle Type Combination | | | |
|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | All |
| Multi-Vehicle | | | | |
| Head-On | $5,406 | $5,227 | $5,048 | $5,310 |
| Rear End | 3,388 | 2,865 | 2,454 | 3,139 |
| Angle | 2,663 | 2,864 | 3,110 | 2,769 |
| Sideswipe | 2,210 | 2,056 | 2,004 | 2,129 |
| Turning | 5,050 | 2,569 | 2,400 | 3,897 |
| Parking | - | - | - | - |
| Other | 1,665 | - | 2,690 | 1,896 |
| All Multi-Vehicle | $3,806 | $3,254 | $3,148 | $3,559 |
| Single-Vehicle | | | | |
| Pedestrian | $1,407 | | $833 | $1,290 |
| Train | 1,889 | | 4,558 | 2,685 |
| Bicycle | 510 | | 1,771 | 749 |
| Animal | 2,169 | | 2,664 | 2,277 |
| Fixed Object | 1,714 | | 2,097 | 1,778 |
| Other Object | 1,650 | | - | 1,650 |
| Non-Collision | $1,838 | | $3,417 | $2,242 |
| ALL | $2,441 | $3,254 | $3,009 | $2,676 |

Table 22

Direct Cost per Injury Accident, by Accident Type and Vehicle Type Combination, Urban, Texas, 1969

| Accident Type | Vehicle Type Combination | | | |
|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | All |
| Multi-Vehicle | | | | |
| Head-On | $1,814 | $2,357 | $2,934 | $1,968 |
| Rear End | 1,788 | 1,283 | 840 | 1,653 |
| Angle | 1,830 | 1,549 | 1,282 | 1,760 |
| Sideswipe | 911 | 1,110 | 1,336 | 991 |
| Turning | 1,493 | 1,385 | 1,284 | 1,463 |
| Parking | 988 | 828 | 668 | 944 |
| Other | 784 | 1,137 | 774 | 788 |
| All Multi-Vehicle | $1,659 | $1,457 | $1,103 | $1,602 |
| Single-Vehicle | | | | |
| Pedestrian | $1,439 | | $1,412 | $1,428 |
| Train | 1,820 | | 2,886 | 1,983 |
| Bicycle | 1,040 | | 633 | 989 |
| Animal | 1,548 | | - | 1,548 |
| Fixed Object | 2,049 | | 1,446 | 1,986 |
| Other Object | 951 | | 215 | 876 |
| Non-Collision | $1,191 | | $1,045 | $1,166 |
| ALL | $1,584 | $1,457 | $1,219 | $1,545 |

rural accidents produce higher costs than urban accidents. In both areas, head-on accidents are still the most costly. The single vehicle accidents, only pedestrian, bicycle, and fixed object collisions are more costly in urban than rural areas. Overall, truck accidents seem to be more costly than car accidents in rural areas, while the opposite holds for accidents in urban areas.

The costs of property damage only accidents (Tables 23-25) show that in this severity class, head-on truck accidents are the most costly of all multi-vehicle accidents. However, the highest cost accident of all types (both multi- and single-vehicle) occurs when trucks over-turn and/or leave the roadway without collision. The rural-urban classification indicates that the more costly multi-vehicular accidents occur in rural areas.

The final set of accident cost estimates (Tables 26-28) combines all severities and includes the loss of future earnings due to fatalities. Under these conditions, accidents involving trains are the most costly of all types of accidents (Table 26). Pedestrian and head-on accidents are the next two highest cost accident types. A comparison of accidents by vehicle-type combination shows that truck-only accidents are twice as costly as car-only accidents. The data in Tables 27 and 28 show that rural accidents are generally much more costly than urban accidents particularly for head-on, train, and pedestrian collisions. Among rural accidents, a truck/train collision has the highest cost; whereas, in urban areas, truck/pedestrian collisions are the most costly.

Table 23

Direct Cost Per Property Damage Only Accident, by Accident Type and Vehicle Type Combination, Texas, 1969

| Accident Type | Vehicle-Type Combination | | | |
|---|---|---|---|---|
| | Car | Car-Truck | Truck | All |
| Multi-Vehicle | | | | |
| Head-On | $470 | $766 | $1,062 | $595 |
| Rear End | 320 | 282 | 242 | 310 |
| Angle | 416 | 375 | 354 | 405 |
| Sideswipe | 258 | 229 | 196 | 246 |
| Turning | 338 | 287 | 236 | 321 |
| Parking | 132 | 135 | 139 | 133 |
| Other | 135 | 236 | 226 | 152 |
| All Multi-Vehicle | $316 | $331 | $ 287 | $318 |
| Single-Vehicle | | | | |
| Pedestrian | - | | - | - |
| Train | $439 | | $1,367 | $685 |
| Bicycle | 61 | | 38 | 58 |
| Animal | 308 | | 607 | 373 |
| Fixed Object | 273 | | 1,018 | 381 |
| Other Object | 91 | | 82 | 89 |
| Non-Collision | 219 | | 1,487 | 499 |
| ALL | $305 | $331 | $ 679 | $334 |

Table 24

Direct Cost per Property Damage Only Accident by Accident Type and Vehicle Type Combination, Rural, Texas, 1969

| Accident Type | Vehicle Type Combination | | | |
|---|---|---|---|---|
| | Car Only | Car-Truck | Truck | All |
| Multi-Vehicle | | | | |
| Head-On | $542 | $1005 | $1468 | $961 |
| Rear End | 578 | 536 | 494 | 538 |
| Angle | 368 | 455 | 544 | 410 |
| Sideswipe | 264 | 316 | 368 | 293 |
| Turning | 618 | 498 | 378 | 551 |
| Parking | 310 | 310 | 310 | 310 |
| Other | 121 | 613 | 1004 | 289 |
| All Multi-Vehicle | $483 | $554 | $ 692 | $525 |
| Single Vehicle | | | | |
| Pedestrian | - | | - | - |
| Train | $172 | | $1809 | $697 |
| Bicycle | - | | - | - |
| Animal | 312 | | 618 | 380 |
| Fixed Object | 377 | | 1872 | 653 |
| Other Object | 93 | | 76 | 89 |
| Non-Collision | $226 | | $1669 | $806 |
| ALL | $364 | $554 | $1108 | $515 |

Table 25

Direct Cost per Property Damage Only Accident, by Accident Type and Vehicle Type Combination, Urban, Texas, 1969

| Accident Type | Vehicle Type Combination | | | |
|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | All |
| Multi-Vehicle | | | | |
| Head-On | $408 | $444 | $480 | $422 |
| Rear End | 282 | 233 | 184 | 270 |
| Angle | 402 | 363 | 324 | 392 |
| Sideswipe | 254 | 191 | 128 | 230 |
| Turning | 290 | 243 | 195 | 276 |
| Parking | 128 | 109 | 90 | 123 |
| Other | 136 | 204 | 160 | 142 |
| All Multi-Vehicle | $298 | $278 | $201 | $290 |
| Single-Vehicle | | | | |
| Pedestrian | - | | - | - |
| Train | $ 706 | | $966 | $773 |
| Bicycle | 61 | | 38 | 58 |
| Animal | 268 | | 180 | 250 |
| Fixed Object | 219 | | 600 | 270 |
| Other Object | 86 | | 78 | 85 |
| Non-Collision | $205 | | $806 | $308 |
| ALL | $286 | $278 | $342 | $287 |

Table 26

Cost per Reported Accident, All Severities, by Accident Type and Vehicle Type Combination, Texas, 1969*(rounded to nearest $100)

| Accident Type | Vehicle Type Combination | | | |
|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | All |
| Multi-Vehicle | | | | |
| Head On | $3,100 | $4,000 | $4,500 | $3,500 |
| Rear End | 600 | 700 | 1,200 | 700 |
| Angle | 900 | 1,000 | 1,200 | 900 |
| Sideswipe | 400 | 400 | 500 | 400 |
| Turning | 700 | 800 | 900 | 700 |
| Parking | 200 | 200 | 200 | 200 |
| Other | 400 | 300 | 400 | 400 |
| All Multi-Vehicle | $ 800 | $1,000 | $ 600 | $ 800 |
| Single Vehicle | | | | |
| Pedestrian | $5,000 | | $5,800 | $5,100 |
| Train | 6,000 | | 8,500 | 6,600 |
| Bicycle | 2,100 | | 2,100 | 2,100 |
| Animal | 500 | | 1,000 | 600 |
| Fixed Object | 1,500 | | 2,500 | 1,600 |
| Other Object | 400 | | 200 | 400 |
| Non-Collision | 1,800 | | 3,300 | 2,100 |
| All | $1,000 | $1,000 | $2,000 | $1,100 |

*Loss of future earnings discounted at 4%.

Table 27

Cost per Accident, All Severities, by Accident Type and Vehicle Type Combination, Rural, Texas, 1969*
(Rounded to nearest $100)

| Accident Type | Vehicle Type Combination | | | |
|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | All |
| Multi-Vehicle | | | | |
| Head-On | $8,900 | $9,300 | $7,400 | $8,900 |
| Rear End | 4,900 | 2,600 | 4,100 | 4,200 |
| Angle | 2,200 | 3,700 | 2,600 | 2,700 |
| Sideswipe | 1,300 | 1,200 | 1,200 | 1,300 |
| Turning | 2,600 | 1,900 | 1,900 | 2,300 |
| Parking | 400 | 300 | 300 | 400 |
| Other | 1,400 | 600 | 2,200 | 1,600 |
| All Multi-Vehicle | $4,000 | $3,700 | $3,400 | $3,800 |
| Single-Vehicle | | | | |
| Pedestrian | $14,100 | | $10,800 | $12,100 |
| Train | 12,200 | | 16,900 | 13,700 |
| Bicycle | 6,000 | | 10,900 | 6,900 |
| Animal | 500 | | 1,100 | 600 |
| Fixed Object | 2,100 | | 3,800 | 2,500 |
| Other Object | 500 | | 600 | 500 |
| Non-Collision | $2,500 | | $3,900 | $2,800 |
| ALL | $2,800 | $3,700 | $3,600 | $3,100 |

* Loss of future earnings discounted at 4%.

Table 28

Cost* per Reported Accident, All Severities, by Accident Type and Vehicle Type Combination, Urban, Texas, 1969*(rounded to nearest $100)

| Accident Type | Vehicle Type Combination | | | |
|---|---|---|---|---|
| | Car Only | Car Truck | Truck Only | All |
| Multi-Vehicle | | | | |
| Head On | $1,500 | $2,200 | $1,500 | $1,700 |
| Rear End | 500 | 600 | 500 | 500 |
| Angle | 700 | 900 | 900 | 700 |
| Sideswipe | 300 | 300 | 400 | 300 |
| Turning | 500 | 500 | 500 | 500 |
| Parking | 200 | 100 | 100 | 200 |
| Other | 200 | 200 | 300 | 200 |
| All Multi-Vehicle | $ 500 | $ 700 | $ 500 | $ 600 |
| Single-Vehicle | | | | |
| Pedestrian | $4,300 | | $5,100 | $4,400 |
| Train | 4,800 | | 4,700 | 4,800 |
| Bicycle | 1,900 | | 1,200 | 1,800 |
| Animal | 500 | | 200 | 500 |
| Fixed Object | 1,300 | | 900 | 1,200 |
| Other Object | 200 | | 100 | 200 |
| Non-Collision | $1,000 | | 1,600 | 1,100 |
| All | $ 700 | $ 700 | $ 900 | $ 700 |

*Loss of future earnings discounted at 4%.

In summary, the data in this section are the result of the implementation of the study design outlined in the section on Research Method. The fatal accident costs in Tables 17-19 do not include estimates for loss of future earnings since fatality data by accident type and vehicle-type combination were not obtained. Users of those tables can easily include the loss of future earnings component by multiplying the number of persons killed per accident by an appropriately selected value from Table 16. The result will be a more comprehensive estimate than those given in Tables 17-19.

## ACCIDENT RATES

The accident rate portion of this study is preliminary and exploratory in its nature. The approach is based on the three-year study by Kihlberg and Tharp.[1] The data utilized are those accidents which occurred in rural areas in Texas in 1969.[2]

The accidents, vehicle miles, and resulting accident rates are classified by accident severity according to highway type and average daily traffic (ADT) classes.

Although no statistical analysis was conducted, the data appear to yield some conclusions which are in accordance with the more intensive study by Kihlberg and Tharp.

Some of the effects of highway design on accident rates are illustrated by the data in Table 29. An overall comparison of highway types suggests that for all accident severities, undivided highways tend to generate higher accident rates than do divided highways. Among undivided highways, those with more than four lanes have much higher accident rates (for fatal and property damage accidents) than any of the other three types of undivided highways. For accidents of all severities, undivided four-lane highways have higher accident rates than undivided two-lane highways.

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[1] J. K. Kihlberg and K. J. Tharp, Accident Rates as Related to Design Elements of Rural Highway, NCHRP Report No. 47, (Washington:Highway Research Board, 1968)

[2] These data were made available for this study by Division 18 of the Texas Highway Department.

Table 29

Rural Accident Rates, by Accident Severity and
Highway Type, Texas, 1969
(accidents per 100 million vehicle miles)

| Highway Type | Accident Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Undivided: * | | | | |
| Two-Lanes | 5.93 | 52.63 | 137.11 | 195.67 |
| Three-Lanes | 2.98 | 48.61 | 169.63 | 221.22 |
| Four-Lanes | 5.98 | 73.78 | 264.61 | 344.36 |
| 4+ Lanes | 18.23 | 54.68 | 729.13 | 802.04 |
| Divided: | | | | |
| Partial-Access Control | | | | |
| Four-Lanes | 3.57 | 31.00 | 70.25 | 104.82 |
| 4+ Lanes | - | - | 155.28 | 155.28 |
| Full-Access Control | | | | |
| Four-Lanes | 3.33 | 25.93 | 67.18 | 96.45 |
| 4+ Lanes | 3.18 | 21.20 | 74.21 | 98.59 |
| All Others | 3.54 | 63.68 | 193.17 | 260.40 |
| TOTAL | 5.33 | 47.72 | 127.33 | 180.38 |

*The discrepancy between the fatal rates on two-lanes and four-lanes, on the one hand, and three-lanes and more-than-four-lanes, on the other hand, is probably due to the inadequate size of the sample of three-lane and more-than-four-lane accidents. Specifically, there were three fatal accidents on three-lane roads and only one fatal accident on roads of more-than-four-lanes. In contrast, there were 1,026 and 38 fatal accidents on two-lane and four-lane roads, respectively.

The effects of access control are indicated by a comparison among types of divided highways. Divided highways with full access control have lower accident rates than divided highways with partial access control. Although the accident rate for all severities is somewhat higher for fully-controlled access highways of more than four-lanes (when compared to fully-controlled access highways of four-lanes), the rates of fatality and injury producing accidents are lower on highways of more than four lanes.

When accident rates are classified by severity and A.D.T. classes, no strongly systematic relationship appears to be present. As the data in Table 30 show, however, some general inferences may be made. First of all, the lowest accident rates in each of the severity categories appear to occur in the highest A.D.T. classes. For fatal accidents and injury, the lowest accident rates appear in highway segments with A.D.T. counts above 7,000. In the case of property damage accidents, the lowest rates occur at A.D.T. levels greater than 8,000.

The determination of those A.D.T. levels generating the highest accident rates is indicated by a clustering effect within severity categories. Thus, for fatal accidents the highest rates tend to cluster between A.D.T. counts of 600 and 4,000. In property damage accidents, two groupings of A.D.T. counts tend to contain the highest accident rates: 400-900 A.D.T. and 2,000-8,000 A.D.T. The highest accident rates for injury accidents lie between the 500 and 1,000 A.D.T. levels.

Although additional data were compiled for accident rates according to severity and further cross-classified by A.D.T. levels and highway

Table 30

Rural Accident Rates, by Accident Severity and Annual Average Daily Traffic, Texas, 1969 (accidents per 100 million vehicle miles)

| A. D. T. Class | Accident Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| 0- 99 | 4.24 | 52.56 | 134.79 | 191.58 |
| 100- 199 | 5.50 | 42.27 | 114.27 | 162.04 |
| 200- 299 | 6.73 | 52.82 | 115.53 | 175.08 |
| 300- 399 | 4.40 | 48.07 | 118.77 | 171.24 |
| 400- 499 | 6.40 | 50.90 | 133.31 | 190.60 |
| 500- 599 | 4.66 | 56.96 | 131.88 | 193.50 |
| 600- 699 | 7.51 | 59.73 | 133.55 | 200.80 |
| 700- 799 | 6.86 | 56.00 | 122.48 | 185.35 |
| 800- 899 | 7.89 | 54.29 | 130.14 | 192.32 |
| 900- 999 | 4.69 | 55.56 | 125.20 | 185.45 |
| 1,000- 1,499 | 6.26 | 51.54 | 125.99 | 183.70 |
| 1,500- 1,999 | 5.19 | 50.03 | 123.66 | 178.88 |
| 2,000- 2,999 | 5.74 | 52.88 | 140.05 | 198.67 |
| 3,000- 3,999 | 5.78 | 51.40 | 145.60 | 202.78 |
| 4,000- 4,999 | 4.74 | 48.72 | 143.61 | 197.08 |
| 5,000- 5,999 | 5.43 | 47.04 | 141.20 | 193.67 |
| 6,000- 6,999 | 4.64 | 48.31 | 152.22 | 205.17 |
| 7,000- 7,999 | 4.13 | 43.76 | 129.35 | 177.24 |
| 8,000- 8,999 | 3.88 | 36.19 | 108.58 | 148.65 |
| 9,000- 9.999 | 5.63 | 35.40 | 102.74 | 143.77 |
| 10,000-14,999 | 3.74 | 24.56 | 78.98 | 107.27 |
| 15,000-19,999 | 3.34 | 40.77 | 117.29 | 161.40 |
| 20,000-29,999 | 2.50 | 27.55 | 92.41 | 122.47 |
| 30,000 + | - | - | - | - |
| All Classes | 5.33 | 47.72 | 127.33 | 180.38 |

types, the effects of disaggregating the data yielded specious results. This is due primarily to the spareseness of data afforded by only a single year's accident experience. Further efforts at more finely cross-classified data could best be made by utilizing accident rate data for a mutli-year (perhaps five) period.

Finally, a thorough study of accident rates probably should incorporate some of the refinements made by Kihlberg and Tharp in Phase II of their work. At a minimum this would include an analytical schema which eliminated the effect upon accident rates caused by variation in the lengths of highway segments.

## Appendix A

An analysis of variance was conducted for four involvement situations to test the hypothesis that no significant difference exists among mean involvement costs for similar involvements occurring in four different states. The involvements selected for testing were:

A. Single - Vehicle, pedestrian, fatal

B. Multi - Vehicle, head-on, injury

C. Multi - Vehicle, rear-end, injury

D. Multi - Vehicle, angle, property damage

The F - values were calculated using:

$$F = \frac{Vm}{Vc} \quad \text{where}$$

$V_m$= variance based on mean cost of involvement in each state.

$V_c$= variance based on variance of mean cost of involvement in each state.

The resulting F values were compared to the 5% critical value of F (for the relevant degrees of freedom) and the results are presented below:

| Involvement | F-Value | 5% F-Value | Accept/Reject Hypothesis |
|---|---|---|---|
| A | 1.688 | 2.605 | Accept |
| B | .642 | 2.605 | Accept |
| C | 1.685 | 2.605 | Accept |
| D | .510 | 2.605 | Accept |

On the basis of these results, it was concluded that the data from the four states were sufficiently similar that they could be combined into a single data-system. Budgetary limitations prevented the analysis from being extended to examine each involvement situation. For each involvement situation cost, the mean cost and standard error of the mean were estimated. The standard error was calculated using: $\frac{SD}{\sqrt{N}}$, where

S.D.= standard deviation of sample

N= size of sample.

Appendix B
Sampling: Population Ratios for Data-States

| Severity | STATE | | | |
| --- | --- | --- | --- | --- |
| | Illinois | Massachusetts | New Mexico | Utah |
| Fatal | 1:4.7 | 1:1 | 1:1 | 1:1 |
| Injury | 1:54.4 | 1:30 | 1:2 | 1:4 |
| P.D.O. | 1:260.2 | - | 1:11 | 1:19 |
| Non-reported | 1:1981.4 | 1:181 | 1:54 | 1:40 |

## Appendix C

### Price Indices[1] Used to Adjust Cost Data

| Year | Consumer Price Index | Meidcal Cost Index |
|---|---|---|
| 1950 | 83.8 | - |
| 1953 | 93.2 | 83.9 |
| 1954 | 93.6 | 86.6 |
| 1955 | 93.3 | 88.6 |
| 1956 | 94.7 | 91.8 |
| 1957 | 98.0 | 95.5 |
| 1958 | 100.7 | 100.1 |
| 1968 | 121.2 | 145.2 |
| 1969 | 127.7 | 155.0 |

[1] U. S. Congress, Economic Report of the President-1970, (Washington:Government Printing Office), 1970, Table C-45, p. 229.

## Appendix D

This appendix presents, in tabular form, involvement frequencies for Texas. These data are compiled from the 1969 Texas accident data tape supplied by The Texas Highway Department for use in this study.

In conjunction with the data in Appendix E, these involvement data have been used to determine the weights to be used in deriving average accident cost estimates.

Table D-1

Reported Involvements, Passenger Cars, By Accident Type and Severity, Texas, 1969

| Accident Type | Severity | | | |
| --- | --- | --- | --- | --- |
| | Fatal | Injury | P.D.O. | All Severities |
| Multi-Vehicle | | | | |
| Head-On | 731 | 4,802 | 16,170 | 21,703 |
| Rear-End | 160 | 23,975 | 119,911 | 144,046 |
| Angle | 612 | 31,782 | 129,351 | 161,745 |
| Sideswipe | 41 | 2,131 | 29,504 | 31,676 |
| Turning | 246 | 11,759 | 66,034 | 78,039 |
| Parking | 2 | 349 | 11,567 | 11,918 |
| Other | 32 | 2,855 | 28,506 | 31,393 |
| Single-Vehicle | | | | |
| Pedestrian | 338 | 3,989 | - | 4,327 |
| Train | 65 | 273 | 410 | 748 |
| Bicycle | 27 | 1,035 | 31 | 1,093 |
| Animal | 9 | 417 | 4,229 | 4,655 |
| Fixed-Object | 431 | 8,543 | 21,492 | 30,466 |
| Other Object | 8 | 241 | 1,074 | 1,323 |
| Non-Collision | 421 | 7,166 | 13,468 | 21,055 |
| Total | 3,123 | 99,317 | 441,747 | 544,187 |

Table D-2

Reported Involvements, Passenger Cars, by Accident Type and Severity, Rural, Texas, 1969

| Accident Type | Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Multi-Vehicle | | | | |
| Head-On | 498 | 1,639 | 3,012 | 5,149 |
| Rear-End | 86 | 2,445 | 7,003 | 9,534 |
| Angle | 180 | 2,281 | 5,661 | 8,122 |
| Sideswipe | 25 | 312 | 1,857 | 2,194 |
| Turning | 121 | 1,838 | 5,744 | 7,703 |
| Parking | - | 2 | 35 | 37 |
| Other | 10 | 133 | 614 | 757 |
| Single-Vehicle | | | | |
| Pedestrian | 82 | 199 | - | 281 |
| Train | 22 | 40 | 58 | 120 |
| Bicycle | 7 | 47 | 3 | 57 |
| Animal | 8 | 309 | 3,601 | 3,918 |
| Fixed-Object | 172 | 1,800 | 4,602 | 6,574 |
| Other Object | 8 | 75 | 242 | 325 |
| Non-Collision | 322 | 4,056 | 6,783 | 11,161 |
| Total | 1,541 | 15,176 | 39,215 | 55,932 |

Table D-3

Reported Involvements, Passenger Cars, by Accident Type and Severity, Urban, Texas, 1969

| Accident Type | Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Multi-Vehicle | | | | |
| Head-On | 233 | 3,163 | 13,158 | 16,554 |
| Rear-End | 74 | 21,530 | 112,908 | 134,512 |
| Angle | 432 | 29,501 | 123,690 | 153,623 |
| Sideswipe | 16 | 1,819 | 27,647 | 29,482 |
| Turning | 125 | 9,921 | 60,290 | 70,336 |
| Parking | 2 | 347 | 11,532 | 11,881 |
| Other | 22 | 2,722 | 27,892 | 30,636 |
| Single-Vehicle | | | | |
| Pedestrian | 256 | 3,790 | - | 4,046 |
| Train | 43 | 233 | 352 | 628 |
| Bicycle | 20 | 988 | 28 | 1,036 |
| Animal | 1 | 108 | 628 | 737 |
| Fixed-Object | 259 | 6,743 | 16,890 | 23,892 |
| Other Object | 0 | 166 | 832 | 998 |
| Non-Collision | 99 | 3,110 | 6,685 | 9,894 |
| Total | 1,582 | 84,141 | 402,532 | 488,255 |

Table D-4

Reported Involvements, Passenger Cars, by Road Characteristics and Severity, Texas, 1969

| Road Characteristic | Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Intersection | 883 | 52,173 | 227,327 | 280,383 |
| Straight | 1,680 | 39,843 | 194,878 | 236,401 |
| Curve | 415 | 6,136 | 17,561 | 24,112 |
| Bridge | 71 | 742 | 1,313 | 2,126 |
| Railroad | 66 | 305 | 449 | 820 |
| Underpass | 8 | 92 | 115 | 215 |
| Interchange | - | - | - | - |
| Tunnel | - | - | - | - |
| Total | 3,123 | 99,291 | 441,643 | 544,057 |

Table D-5

Reported Involvements at Intersections Passenger Cars, by Type of Traffic Control and Severity, Texas, 1969

| Type of Control | Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Stop-Go Light | 161 | 18,434 | 83,622 | 102,217 |
| Officer | 7 | 314 | 1,238 | 1,559 |
| Flashing Light | 23 | 747 | 1,901 | 2,671 |
| Stop Sign | 345 | 15,967 | 64,147 | 80,459 |
| Yield Sign | 61 | 2,572 | 11,887 | 14,520 |
| Warning Sign | 64 | 727 | 2,022 | 2,813 |
| Other & No Control | 222 | 13,412 | 62,510 | 76,144 |
| Total | 883 | 52,173 | 227,327 | 280,383 |

Table D-6

Reported Involvements, Single-Unit Trucks, by Accident Type and Severity, Texas, 1969

| Accident Type | Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Multi-Vehicle | | | | |
| Head-On | 145 | 915 | 3,711 | 4,771 |
| Rear-End | 74 | 3,470 | 15,968 | 19,512 |
| Angle | 141 | 4,539 | 18,698 | 23,378 |
| Sideswipe | 5 | 408 | 6,039 | 6,452 |
| Turning | 57 | 1,946 | 11,516 | 13,519 |
| Parking | - | 49 | 1,719 | 1,768 |
| Other | 7 | 306 | 5,171 | 5,484 |
| Single-Vehicle | | | | |
| Pedestrian | 55 | 558 | - | 613 |
| Train | 18 | 46 | 96 | 160 |
| Bicycle | 5 | 151 | 4 | 160 |
| Animal | 4 | 82 | 913 | 999 |
| Fixed-Object | 75 | 1,058 | 2,598 | 3,731 |
| Other Object | - | 34 | 165 | 199 |
| Non-Collision | 107 | 1,689 | 2,631 | 4,427 |
| Total | 693 | 15,251 | 69,229 | 85,173 |

Table D-7

Reported Involvements, Single-Unit Trucks, by Accident Type and Severity, Rural, Texas, 1969

| Accident Type | Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Multi-Vehicle | | | | |
| Head-On | 106 | 447 | 991 | 1,544 |
| Rear End | 48 | 565 | 1,439 | 2,052 |
| Angle | 59 | 673 | 1,592 | 2,324 |
| Sideswipe | 4 | 71 | 499 | 574 |
| Turning | 32 | 546 | 1,917 | 2,495 |
| Parking | – | – | 10 | 10 |
| Other | 3 | 23 | 193 | 219 |
| Single-Vehicle | | | | |
| Pedestrian | 10 | 46 | – | 56 |
| Train | 8 | 13 | 16 | 37 |
| Bicycle | 3 | 11 | – | 14 |
| Animal | 3 | 72 | 790 | 865 |
| Fixed-Object | 42 | 370 | 728 | 1,140 |
| Other Object | – | 18 | 42 | 60 |
| Non-Collision | 87 | 1,120 | 1,646 | 2,853 |
| Total | 405 | 3,975 | 9,863 | 14,243 |

Table D-8

Reported Involvements, Single-Unit Trucks, By Accident Type and Severity, Urban, Texas, 1969

| Accident Type | Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Multi-Vehicle | | | | |
| Head<br>Head-On | 39 | 468 | 2,720 | 3,227 |
| Rear-End | 26 | 2,905 | 14,529 | 17,460 |
| Angle | 82 | 3,866 | 17,106 | 21,054 |
| Sideswipe | 1 | 337 | 5,540 | 5,878 |
| Turning | 25 | 1,400 | 9,599 | 11,024 |
| Parking | - | 49 | 1,709 | 1,758 |
| Other | 4 | 283 | 4,978 | 5,265 |
| Single-Vehicle | | | | |
| Pedestrian | 45 | 512 | - | 557 |
| Train | 10 | 33 | 80 | 123 |
| Bicycle | 2 | 140 | 4 | 146 |
| Animal | 1 | 10 | 123 | 134 |
| Fixed-Object | 33 | 688 | 1,870 | 2,591 |
| Other Object | - | 16 | 123 | 139 |
| Non-Collision | 20 | 569 | 985 | 1,574 |
| Total | 288 | 11,276 | 59,366 | 70,930 |

Table D-9

Reported Involvements, Single-Unit Truck, by Road Characteristics and Severity, Texas, 1969

| Road Characteristic | Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Intersection | 211 | 7,341 | 32,791 | 40,343 |
| Straight | 366 | 6,594 | 33,114 | 40,074 |
| Curve | 76 | 1,097 | 2,942 | 4,115 |
| Bridge | 21 | 144 | 211 | 376 |
| Railroad | 19 | 49 | 111 | 179 |
| Underpass | - | 24 | 37 | 61 |
| Interchange | - | - | - | - |
| Tunnel | - | - | - | - |
| Total | 693 | 15,249 | 69,206 | 85,148 |

Table D-10

Reported Involvements at Intersections, Single-Unit Trucks
Type of Traffic Control and Severity, Texas, 1969

| Type of Control | Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Stop-Go Light | 33 | 2,352 | 11,490 | 13,875 |
| Officer | 6 | 56 | 255 | 317 |
| Flashing Light | 6 | 105 | 314 | 425 |
| Stop Sign | 89 | 2,219 | 8,732 | 11,040 |
| Yield Sign | 12 | 384 | 1,617 | 2,013 |
| Warning | 17 | 140 | 361 | 518 |
| Other & No Control | 48 | 2,085 | 10,022 | 12,155 |
| Total | 211 | 7,341 | 32,791 | 40,343 |

Table D-11

Reported Involvements, Truck Combinations, by Accident Type and Severity, Texas, 1969

| Accident Type | Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Multi-Vehicle | | | | |
| Head-On | 94 | 195 | 618 | 907 |
| Rear-End | 47 | 614 | 1,860 | 2,521 |
| Angle | 65 | 429 | 1,188 | 1,682 |
| Sideswipe | 8 | 159 | 1,358 | 1,525 |
| Turning | 26 | 296 | 1,620 | 1,942 |
| Parking | - | 2 | 47 | 49 |
| Other | 3 | 24 | 622 | 649 |
| Single-Vehicle | | | | |
| Pedestrian | 10 | 24 | - | 34 |
| Train | 3 | 13 | 51 | 67 |
| Bicycle | - | 2 | - | 2 |
| Animal | 3 | 13 | 256 | 272 |
| Fixed-Object | 15 | 200 | 1,040 | 1,255 |
| Other Object | 1 | 6 | 53 | 60 |
| Non-Collision | 33 | 351 | 1,172 | 1,556 |
| Total | 308 | 2,328 | 9,885 | 12,521 |

Table D-12

Reported Involvements, Truck Combinations, by Accident Type and Severity, Rural, Texas, 1969

| Accident Type | Severity | | | |
| --- | --- | --- | --- | --- |
| | Fatal | Injury | P.D.O. | All Severities |
| Multi-Vehicle | | | | |
| Head-On | 76 | 142 | 225 | 443 |
| Rear-End | 30 | 226 | 363 | 619 |
| Angle | 24 | 108 | 187 | 319 |
| Sideswipe | 6 | 55 | 235 | 296 |
| Turning | 14 | 104 | 303 | 421 |
| Parking | - | - | 2 | 2 |
| Other | 1 | 7 | 46 | 54 |
| Single-Vehicle | | | | |
| Pedestrian | 5 | 5 | - | 10 |
| Train | 3 | 4 | 10 | 17 |
| Bicycle | - | - | - | - |
| Animal | 3 | 11 | 217 | 231 |
| Fixed-Object | 8 | 110 | 307 | 425 |
| Other Object | 1 | 4 | 30 | 35 |
| Non-Collision | 25 | 268 | 775 | 1,068 |
| Total | 196 | 1,044 | 2,700 | 3,940 |

Table D-13

Report Involvements, Combination Truck, by Accident Type and Severity, Urban, Texas, 1969

| Accident Type | Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Multi-Vehicle: | | | | |
| Head-On | 18 | 53 | 393 | 464 |
| Rear End | 17 | 388 | 1,497 | 1,902 |
| Angle | 41 | 321 | 1,001 | 1,363 |
| Sideswipe | 2 | 104 | 1,123 | 1,229 |
| Turning | 12 | 192 | 1,317 | 1,521 |
| Parking | - | 2 | 45 | 47 |
| Other | 2 | 17 | 576 | 595 |
| Single-Vehicle: | | | | |
| Pedestrian | 5 | 19 | - | 24 |
| Train | - | 9 | 41 | 50 |
| Bicycle | - | 2 | - | 2 |
| Animal | - | 2 | 39 | 41 |
| Fixed Object | 7 | 90 | 733 | 830 |
| Other Object | - | 2 | 23 | 25 |
| Non-Collision | 8 | 83 | 397 | 488 |
| Total | 112 | 1,284 | 7,185 | 8,581 |

Table D-14

Reported Involvements, Truck Combination, by Road Characteristics and Severity, Texas, 1969

| Road Characteristics | Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Intersection | 77 | 817 | 3,804 | 4,698 |
| Straight | 186 | 1,212 | 5,083 | 6,481 |
| Curve | 35 | 237 | 782 | 1,054 |
| Bridge | 7 | 36 | 72 | 115 |
| Railroad | 3 | 14 | 53 | 70 |
| Underpass | - | 12 | 85 | 97 |
| Interchange | - | - | - | - |
| Tunnel | - | - | - | - |
| Total | 308 | 2,328 | 9,879 | 12,515 |

Table D-15

Reported Involvements at Intersections, Truck Combination, by Type of Traffic Control and Severity, Texas, 1969

| Type of Control | Severity | | | |
|---|---|---|---|---|
| | Fatal | Injury | P.D.O. | All Severities |
| Stop-Go Light | 10 | 299 | 1,609 | 1,918 |
| Officer | 3 | 18 | 60 | 81 |
| Flashing Light | 5 | 27 | 47 | 79 |
| Stop Sign | 31 | 199 | 687 | 917 |
| Yield Sign | 8 | 39 | 158 | 205 |
| Warning Sign | 4 | 37 | 131 | 172 |
| Other & No Control | 16 | 198 | 1,112 | 1,326 |
| Total | 77 | 817 | 3,804 | 4,698 |

## Appendix E

This appendix presents, in tabular form, accident frequency data for Texas. The data are compiled from the 1969 Texas accident data tape supplied by The Texas Highway Department for use in this study.

In conjunction with the data in Appendix D, these accident data have been used to determine the weights to be used in deriving average accident cost estimates.

Table E-1

Reported Fatal Accidents by Accident Type, Vehicle Type Combination, Texas, 1969

| Accident Type | Vehicle Type Combination | | | | | | |
|---|---|---|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | Car-Other | Truck-Other | Other | Total |
| Multi-Vehicle | | | | | | | |
| Head On | 258 | 176 | 29 | 10 | 3 | - | 476 |
| Rear End | 41 | 64 | 25 | 6 | 7 | - | 143 |
| Angle | 218 | 154 | 21 | 15 | 7 | - | 415 |
| Sideswipe | 16 | 7 | 2 | - | - | - | 25 |
| Turning | 86 | 57 | 10 | 15 | 6 | - | 174 |
| Parking | 1 | - | - | - | - | - | 1 |
| Other | 32 | - | 10 | - | - | 2 | 44 |
| Sub-Total | 652 | 458 | 97 | 46 | 23 | 2 | 1,278 |
| Single-Vehicle | | | | | | | |
| Pedestrian | 333 | - | 64 | - | - | 9 | 406 |
| Train | 65 | - | 21 | - | - | - | 86 |
| Bicycle | 27 | - | 5 | - | - | - | 32 |
| Animal | 8 | - | 7 | - | - | - | 15 |
| Fixed Object | 401 | - | 89 | - | - | 13 | 503 |
| Other Object | 3 | - | 1 | - | - | 1 | 5 |
| Non-Collision | 412 | - | 139 | - | - | 19 | 570 |
| ALL | 1,901 | 458 | 423 | 46 | 23 | 44 | 2,895 |

Table E-2

Reported Fatal Accidents by Accident Type and Vehicle Type Combinations, Rural, Texas, 1969

| Accident Type | Vehicle Type Combinations | | | | | | |
|---|---|---|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | Car-Other | Truck-Other | Other | Total |
| Multi-Vehicle | | | | | | | |
| Head On | 171 | 132 | 24 | 6 | 2 | - | 335 |
| Rear End | 20 | 38 | 18 | 5 | 4 | - | 85 |
| Angle | 55 | 67 | 7 | 2 | 2 | - | 133 |
| Sideswipe | 9 | 6 | 1 | - | - | - | 16 |
| Turning | 41 | 29 | 7 | 8 | 3 | - | 88 |
| Parking | - | - | - | - | - | - | - |
| Other | 10 | - | 4 | - | - | - | 14 |
| Sub-Total | 306 | 272 | 61 | 21 | 11 | - | 671 |
| Single-Vehicle | | | | | | | |
| Pedestrian | 81 | - | 15 | - | - | 2 | 98 |
| Train | 22 | - | 11 | - | - | - | 33 |
| Bicycle | 7 | - | 3 | - | - | - | 10 |
| Animal | 7 | - | 6 | - | - | - | 13 |
| Fixed Object | 159 | - | 49 | - | - | 5 | 213 |
| Other Object | 3 | - | 1 | - | - | 1 | 5 |
| Non-Collision | 316 | - | 111 | - | - | 15 | 442 |
| ALL | 901 | 272 | 257 | 21 | 11 | 23 | 1,485 |

Table E-3

Reported Fatal Accidents By Accident Type and Vehicle Type Combination, Urban, Texas, 1969

| Accident Type | Vehicle Type Combinations | | | | | | |
|---|---|---|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | Car-Other | Truck-Other | Other | Total |
| Multi-Vehicle | | | | | | | |
| Head On | 87 | 44 | 5 | 4 | 1 | - | 141 |
| Rear End | 21 | 26 | 7 | 1 | 3 | - | 58 |
| Angle | 163 | 87 | 14 | 13 | 5 | - | 282 |
| Sideswipe | 7 | 1 | 1 | - | - | - | 9 |
| Turning | 45 | 28 | 3 | 7 | 3 | - | 86 |
| Parking | 1 | - | - | - | - | - | 1 |
| Other | 22 | - | 6 | - | - | 2 | 30 |
| Sub-Total | 346 | 186 | 36 | 25 | 12 | 2 | 607 |
| Single-Vehicle | | | | | | | |
| Pedestrian | 252 | - | 49 | - | - | 7 | 308 |
| Train | 43 | - | 10 | - | - | - | 53 |
| Bicycle | 20 | - | 2 | - | - | - | 22 |
| Animal | 1 | - | 1 | - | - | - | 2 |
| Fixed Object | 242 | - | 40 | - | - | 8 | 290 |
| Other Object | - | - | - | - | - | - | - |
| Non-Collision | 96 | - | 28 | - | - | 4 | 128 |
| ALL | 1,000 | 186 | 166 | 25 | 12 | 21 | 1,410 |

Table E-4

Reported Injury Accidents by Accident Type, Vehicle Type Combinations, Texas, 1969

| Accident Type | Vehicle Type Combinations | | | | | | |
|---|---|---|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | Car-Other | Truck-Other | Other | Total |
| Multi-Vehicle | | | | | | | |
| Head On | 1,923 | 799 | 141 | 86 | 21 | 4 | 2,974 |
| Rear End | 9,879 | 3,140 | 411 | 367 | 73 | 30 | 13,900 |
| Angle | 13,257 | 3,974 | 405 | 1,085 | 166 | 10 | 18,897 |
| Sideswipe | 784 | 426 | 56 | 86 | 22 | 13 | 1,387 |
| Turning | 4,574 | 1,666 | 211 | 891 | 140 | 24 | 7,515 |
| Parking | 143 | 36 | 7 | 28 | 1 | - | 215 |
| Other | 2,683 | 38 | 282 | 15 | 3 | 91 | 3,112 |
| Sub-Total | 33,243 | 10,079 | 1,513 | 2,558 | 435 | 172 | 48,000 |
| Single-Vehicle | | | | | | | |
| Pedestrian | 3,986 | - | 582 | - | - | 98 | 4,666 |
| Train | 272 | - | 59 | - | - | 3 | 334 |
| Bicycle | 1,035 | - | 153 | - | - | 32 | 1,220 |
| Animal | 406 | - | 95 | - | - | 38 | 539 |
| Fixed Object | 8,364 | - | 1,250 | - | - | 315 | 9,929 |
| Other Ojbect | 321 | - | 40 | - | - | 14 | 285 |
| Non-Collision | 7,130 | - | 2,038 | - | - | 633 | 9,801 |
| ALL | 54,667 | 10,079 | 5,730 | 2,558 | 435 | 1,314 | 74,774 |

Table E-5

Reported Injury Accidents by Accident Type,
Vehicle Type Combinations, Rural, Texas, 1969

| Accident Type | Vehicle Type Combinations | | | | | | |
|---|---|---|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | Car-Other | Truck-Other | Other | Total |
| Multi-Vehicle | | | | | | | |
| Head On | 606 | 379 | 100 | 28 | 8 | 1 | 1,122 |
| Rear End | 917 | 506 | 130 | 42 | 16 | 5 | 1,616 |
| Angle | 825 | 548 | 105 | 61 | 20 | 2 | 1,561 |
| Sideswipe | 103 | 90 | 14 | 6 | 7 | - | 220 |
| Turning | 643 | 457 | 89 | 77 | 14 | 5 | 1,285 |
| Parking | 1 | - | - | - | - | - | 1 |
| Other | 129 | - | 29 | - | - | 2 | 160 |
| Sub-Total | 3,224 | 1,980 | 467 | 214 | 65 | 15 | 5,965 |
| Single-Vehicle | | | | | | | |
| Pedestrian | 199 | - | 51 | - | - | 1 | 251 |
| Train | 40 | - | 17 | - | - | - | 57 |
| Bicycle | 47 | - | 11 | - | - | 3 | 61 |
| Animal | 299 | - | 83 | - | - | 15 | 397 |
| Fixed Object | 1,767 | - | 475 | - | - | 42 | 2,284 |
| Other Object | 72 | - | 22 | - | - | 9 | 103 |
| Non-Collision | 4,034 | - | 1,387 | - | - | 158 | 5,579 |
| ALL | 9,682 | 1,980 | 2,513 | 214 | 65 | 243 | 14,697 |

Table E-6

Reported Injury Accidents by Accident Type, Vehicle Type, Combinations, Urban, Texas, 1969

| Accident Type | Vehicle Type Combination | | | | | | |
|---|---|---|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | Car-Other | Truck-Other | Other | Total |
| Mulit-Vehicle | | | | | | | |
| Head On | 1,317 | 420 | 41 | 58 | 13 | 3 | 1,852 |
| Rear End | 8,962 | 2,634 | 281 | 325 | 57 | 25 | 12,284 |
| Angle | 12,432 | 3,426 | 300 | 1,024 | 146 | 8 | 17,336 |
| Sideswipe | 681 | 336 | 42 | 80 | 15 | 13 | 1,167 |
| Turning | 3,931 | 1,209 | 122 | 814 | 135 | 19 | 6,230 |
| Parking | 142 | 36 | 7 | 28 | 1 | - | 214 |
| Other | 2,554 | 38 | 253 | 15 | 3 | 89 | 2,952 |
| Sub-Total | 30,019 | 8,099 | 1,046 | 2,344 | 370 | 157 | 42,035 |
| Single Vehicle | | | | | | | |
| Pedestrian | 3,787 | - | 531 | - | - | 97 | 4,415 |
| Train | 232 | - | 42 | - | - | 3 | 277 |
| Bicycle | 988 | - | 142 | - | - | 29 | 1,159 |
| Animal | 107 | - | 12 | - | - | 23 | 142 |
| Fixed Object | 6,597 | - | 775 | - | - | 273 | 7,645 |
| Other Object | 159 | - | 18 | - | - | 5 | 182 |
| Non-Collision | 3,096 | - | 651 | - | - | 475 | 4,222 |
| ALL | 44,985 | 8,099 | 3,217 | 2,344 | 370 | 1,062 | 60,077 |

Table E-7

Reported Property Damage Accidents by Accident Type, Vehicle Type Combinations, Texas, 1969

| Accident Type | Vehicle Type Combinations | | | | | | |
|---|---|---|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | Car-Other | Truck-Other | Other | Total |
| Multi-Vehicle | | | | | | | |
| Head On | 6,451 | 3,326 | 498 | 162 | 34 | - | 10,471 |
| Rear End | 52,755 | 14,479 | 1,660 | 641 | 97 | 21 | 69,653 |
| Angle | 56,361 | 16,249 | 1,781 | 916 | 117 | 7 | 75,431 |
| Sideswipe | 11,768 | 6,041 | 677 | 256 | 49 | 5 | 18,796 |
| Turning | 27,490 | 10,548 | 1,258 | 745 | 104 | 9 | 40,154 |
| Parking | 4,995 | 1,553 | 102 | 64 | 13 | - | 6,727 |
| Other | 25,054 | 965 | 4,725 | 45 | 8 | 221 | 30,988 |
| Sub-Total | 184,844 | 53,161 | 10,701 | 2,829 | 422 | 263 | 252,220 |
| Single-Vehicle | | | | | | | |
| Pedestrian | - | - | - | - | - | - | - |
| Train | 407 | - | 147 | - | - | 4 | 558 |
| Bicycle | 31 | - | 4 | - | - | 1 | 36 |
| Animal | 4,219 | - | 1,169 | - | - | 20 | 5,408 |
| Fixed Object | 21,461 | - | 3,363 | - | - | 102 | 25,200 |
| Other Object | 1,073 | - | 218 | - | - | 10 | 1,301 |
| Non-Collision | 13,440 | - | 3,801 | - | - | 123 | 17,364 |
| ALL | 225,475 | 53,161 | 19,677 | 2,289 | 422 | 523 | 302,087 |

Table E-8

Reported Property Damage Accidents by Accident Type and Vehicle Type Combinations, Rural, Texas, 1969

| Accident Type | Vehicle Type Combination | | | | | | |
|---|---|---|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | Car-Other | Truck-Other | Other | Total |
| Multi-Vehicle: | | | | | | | |
| Head On | 1,107 | 801 | 204 | 35 | 14 | - | 2,161 |
| Rear End | 2,855 | 1,281 | 255 | 57 | 17 | 3 | 4,468 |
| Angle | 2,186 | 1,230 | 268 | 68 | 16 | - | 3,768 |
| Sideswipe | 660 | 544 | 93 | 20 | 8 | - | 1,325 |
| Turning | 2,070 | 1,553 | 326 | 58 | 15 | - | 4,022 |
| Parking | 12 | 10 | 1 | 1 | - | - | 24 |
| Other | 538 | 26 | 206 | 2 | - | 7 | 779 |
| Sub-Total | 9,428 | 5,445 | 1,353 | 241 | 70 | 10 | 16,547 |
| Single-Vehicle: | | | | | | | |
| Pedestrian | - | - | - | - | - | - | - |
| Train | 55 | - | 26 | - | - | 1 | 82 |
| Bicycle | 3 | - | - | - | - | - | 3 |
| Animal | 3,591 | - | 1,007 | - | - | 14 | 4,612 |
| Fixed Object | 4,579 | - | 1,035 | - | - | 12 | 5,626 |
| Other Object | 242 | - | 72 | - | - | 2 | 316 |
| Non-Collision: | 6,763 | - | 2,420 | - | - | 28 | 9,211 |
| ALL | 24,661 | 5,445 | 5,913 | 241 | 70 | 67 | 36,397 |

Table E-9

Reported Property Damage Accidents by Accident Type, Vehicle Type Combinations, Urban, Texas, 1969

| Accident Type | Vehicle Type Combinations | | | | | | |
|---|---|---|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | Car-Other | Truck-Other | Other | Total |
| Multi-Vehicle: | | | | | | | |
| Head-On | 5,344 | 2,525 | 294 | 127 | 20 | - | 8,310 |
| Rear End | 49,900 | 13,198 | 1,405 | 584 | 80 | 18 | 65,185 |
| Angle | 54,175 | 15,019 | 1,513 | 848 | 101 | 7 | 71,663 |
| Sideswipe | 11,108 | 5,497 | 584 | 236 | 41 | 5 | 17,471 |
| Turning | 25,420 | 8,995 | 932 | 687 | 89 | 9 | 36,132 |
| Parking | 4,983 | 1,543 | 101 | 63 | 13 | - | 6,703 |
| Other | 24,486 | 939 | 4,519 | 43 | 8 | 214 | 30,209 |
| Sub-Total | 175,416 | 47,716 | 9,348 | 2,348 | 352 | 253 | 235,673 |
| Single-Vehicle: | | | | | | | |
| Pedestrian | - | - | - | - | - | - | - |
| Train | 352 | - | 121 | - | - | 3 | 476 |
| Bicycle | 28 | - | 4 | - | - | 1 | 33 |
| Animal | 628 | - | 162 | - | - | 6 | 796 |
| Fixed-Object | 16,882 | - | 2,602 | - | - | 90 | 19,574 |
| Other-Object | 831 | - | 146 | - | - | 8 | 985 |
| Non-Collision | 6,677 | - | 1,381 | - | - | 95 | 8,153 |
| ALL | 200,814 | 47,716 | 13,764 | 2,588 | 352 | 456 | 265,690 |

Table E-10

Reported Accidents, ALL severities, by Accident Type, Vehicle Type Combination, Texas, 1969

| Accident Type | Vehicle Type Combinations | | | | | | |
|---|---|---|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | Car-Other | Truck-Other | Other | Total |
| Multi-Vehicle: | | | | | | | |
| Head On | 8,632 | 4,301 | 668 | 258 | 58 | 4 | 13,921 |
| Rear End | 62,675 | 17,683 | 2,096 | 1,014 | 177 | 51 | 83,696 |
| Angle | 69,836 | 20,377 | 2,207 | 2,016 | 290 | 17 | 94,743 |
| Sideswipe | 12,568 | 6,474 | 735 | 342 | 71 | 18 | 20,208 |
| Turning | 32,150 | 12,271 | 1,479 | 1,651 | 259 | 33 | 47,843 |
| Parking | 5,139 | 1,589 | 109 | 92 | 14 | - | 6,943 |
| Other | 27,739 | 1,003 | 5,017 | 60 | 11 | 314 | 34,144 |
| All Multi-Vehicle | 218,739 | 63,698 | 12,311 | 5,433 | 880 | 437 | 301,498 |
| Single-Vehicle | | | | | | | |
| Pedestrian | 4,319 | - | 646 | - | - | 116 | 5,081 |
| Train | 744 | - | 227 | - | - | 7 | 978 |
| Bicycle | 1,093 | - | 162 | - | - | 33 | 1,288 |
| Animal | 4,633 | - | 1,271 | - | - | 58 | 5,962 |
| Fixed-Object | 30,226 | - | 4,976 | - | - | 430 | 35,632 |
| Other-Object | 1,307 | - | 259 | - | - | 25 | 1,591 |
| Non-Collision | 20,982 | - | 5,978 | - | - | 775 | 27,735 |
| ALL | 282,043 | 63,701 | 25,827 | 5,433 | 880 | 1,881 | 379,765 |

Table E-11

Reported Accidents, All Severities, by Accident Type, Vehicle Type Combination, Rural, Texas, 1969

| Accident Type | Vehicle Type Combination | | | | | | |
|---|---|---|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | Car-Other | Truck-Other | Other | Total |
| Multi-Vehicle: | | | | | | | |
| Head On | 1,884 | 1,312 | 328 | 69 | 24 | 1 | 3,618 |
| Rear End | 3,792 | 1,825 | 403 | 104 | 37 | 8 | 6,169 |
| Angle | 3,066 | 1,845 | 380 | 131 | 38 | 2 | 5,462 |
| Sideswipe | 772 | 640 | 108 | 26 | 15 | - | 1,561 |
| Turning | 2,754 | 2,039 | 422 | 143 | 32 | 5 | 5,395 |
| Parking | 13 | 10 | 1 | 1 | - | - | 25 |
| Other | 677 | 26 | 239 | 2 | - | 9 | 953 |
| All Multi-Vehicle | 12,958 | 7,697 | 1,881 | 476 | 146 | 25 | 23,183 |
| Single-Vehicle: | | | | | | | |
| Pedestrian | 280 | - | 66 | - | - | 12 | 358 |
| Train | 117 | - | 54 | - | - | 1 | 172 |
| Bicycle | 57 | - | 14 | - | - | 3 | 74 |
| Animal | 3,897 | - | 1,096 | - | - | 29 | 5,022 |
| Fixed-Object | 6,505 | - | 1,559 | - | - | 59 | 8,123 |
| Other-Object | 317 | - | 95 | - | - | 12 | 424 |
| Non-Collision | 11,113 | - | 3,918 | - | - | 201 | 15,232 |
| ALL | 35,244 | 7,697 | 8,683 | 146 | 146 | 342 | 52,588 |

Table E-12

Reported Accidents, All Severities, by
Accident Type, Vehicle Type Combination,
Urban, Texas, 1969

| Accident Type | Vehicle Type Combination | | | | | | |
|---|---|---|---|---|---|---|---|
| | Car Only | Car-Truck | Truck Only | Car Other | Truck Other | Other | Total |
| Multi-Vehicle: | | | | | | | |
| Head-On | 6,748 | 2,989 | 340 | 189 | 34 | 3 | 10,303 |
| Rear End | 58,883 | 15,858 | 1,693 | 910 | 140 | 43 | 77,527 |
| Angle | 66,770 | 18,532 | 1,827 | 1,885 | 252 | 15 | 89,281 |
| Sideswipe | 11,796 | 5,834 | 627 | 316 | 56 | 18 | 18,647 |
| Turning | 29,396 | 10,232 | 1,057 | 1,508 | 227 | 28 | 42,448 |
| Parking | 5,126 | 1,579 | 108 | 91 | 14 | - | 6,918 |
| Other | 27,062 | 977 | 4,778 | 58 | 11 | 305 | 33,191 |
| All Multi-Vehicle | 205,781 | 56,001 | 10,430 | 4,957 | 734 | 412 | 278,315 |
| Single-Vehicle: | | | | | | | |
| Pedestrian | 4,039 | - | 578 | - | - | 104 | 4,723 |
| Train | 627 | - | 173 | - | - | 6 | 806 |
| Bicycle | 1,036 | - | 148 | - | - | 30 | 1,214 |
| Animal | 736 | - | 175 | - | - | 29 | 940 |
| Fixed Object | 23,721 | - | 3,417 | - | - | 371 | 27,509 |
| Other Object | 990 | - | 164 | - | - | 13 | 1,167 |
| Non-Collision | 9,869 | - | 2,060 | - | - | 574 | 12,503 |
| ALL | 246,799 | 56,001 | 17,147 | 4,957 | 734 | 1,539 | 327,177 |

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