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ESTIMATES OF DIRECT COSTS TO THE STATE RESULTING FROM TRAFFIC ACCIDENTS

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THE UNIVERSITY OF MICHIGAN
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16. Abstract

This is the final report for the project entitled "Estimates of Direct State Costs to the State Resulting From Traffic Accidents," sponsored by the State of Michigan Office of Highway Safety Planning. The project aimed to provide quantitative estimates of traffic accident-related direct expenditures from state tax revenues as a result of traffic accidents.

This report serves three purposes. The first is to detail the methodology and the sources of data. The second is to present estimates of the costs. The third is to show how the cost estimates can be used to estimate the likely benefits of countermeasures related to highway safety.

The estimated annual direct cost to the state has been computed to be 21.5 million dollars, with 13.9 million associated primarily with injuries, 2.7 million with property damage, and 4.9 million associated with both injuries and property damage.

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SUMMARY

This is the final report for the project entitled "Estimates of Direct Costs to the State Resulting From Traffic Accidents," sponsored by the State of Michigan Office of Highway Safety Planning. The project aimed to provide quantitative estimates of the costs of traffic accidents that are paid directly from state tax revenues.

The project first determined the components of direct state cost. Nine components were identified. They were:

(1) Care in State Institutions
(2) Medicaid
(3) Aid to Dependent Children (ADC)
(4) State Employees Sick Leave
(5) Litigation and Judgments
(6) Special Education and Crippled Children's Fund
(7) Unreimbursed Road Repairs
(8) Auto Insurance for State-owned Vehicles
(9) Workers' Compensation

Estimates of annual expenditures for each of these nine components were then derived. For litigation and judgment costs, unreimbursed road repair costs, and auto insurance costs, estimates are based on primary data sources. The costs for special education and for the Crippled Children's Fund are based on estimates of the number of individuals involved, combined with a known cost per individual. State employees' sick leave, Workers' Compensation, Medicaid, and ADC costs were estimated by an extrapolation method, since the cases resulting from traffic accidents could not be directly determined.

The cost components given above may be classified into three types. They are:

(1) Costs Resulting From Property Damage
(2) Costs Resulting From Injuries
(3) Costs Resulting From Both Injuries and Property Damage.

Unreimbursed road repair costs result from property damage. Litigation and judgment costs, as well as auto insurance for state-owned vehicles, result from both injuries and property damage. All other components of direct state cost result from injuries.

The best estimates of each component of direct cost to the State are summarized in the table below.

Cost Estimates

Component	Estimated Annual Cost in Millions of Dollars
Care in State Institutions	$0.4
Medicaid	8.9
ADC	3.1
State Employees Sick Leave	0.7
Litigation and Judgments	3.6
Special Education	0.5
Crippled Children's Fund	0.1
Unreimbursed Road Repairs	2.7
Auto Insurance for State-owned Vehicles	1.3
Workers' Compensation	0.2
Total	$21.5

The total direct state cost was estimated to be 21.5 million dollars annually. That includes 13.9 million resulting from injuries, 2.7 million resulting from property damage, and 4.9 million resulting from both injuries and property damage.

The cost estimates given above provide a means of estimating likely benefits from countermeasures related to highway safety. Such countermeasures are introduced with the ultimate purpose of reducing the number of accidents and/or injuries within the jurisdiction. Changes in

driver licensing policies, vehicle inspection procedures, requirements for using protective equipment, etc., are continually proposed. With emphasis on cost/benefit justification, the results of this study can be used to calculate the net benefit to the State of proposed countermeasures.

During this study the Michigan Department of Social Services modified its record keeping procedures so that Medicaid expenditures for treatment of traffic accident victims may be separately identified. While these data did not become available in time for inclusion in the present study, any future analyses should acquire and process this information to replace the less direct estimates used in this report.

Finally, the expenditure estimates reported here are restricted to those items directly paid from state tax revenues. Many other traffic accident/injury-related expenditures are made from "the public's" money in the sense that most citizens contribute to medical and automobile insurance plans. With automobile insurance mandated by law and medical insurance nearly universal in this state, the possible cost reductions to the public are much larger than those estimated as state tax reduction. This, too, might be considered in a further study.

1.0 INTRODUCTION

The costs of highway accidents constitute a continuing and increasing burden on the residents of Michigan. Many proposed highway safety countermeasures require the expenditure of funds by the state or local governments, and most should also provide benefits which may return such expenditures to the people or their governments. Motorcycle helmet legislation, for example, was reaffirmed by the Massachusetts court in Simon vs. Sargent (346 F.Supp. 278 [d. Mass.], affirmed, 409 U.S. 1020 [1972]):

> "From the moment of the injury, society picks the person up off the highway; delivers him to a municipal hospital and municipal doctors; provides him with unemployment compensation if, after recovery, he cannot replace his lost job, and, if the injury causes permanent disability, may assume the responsibility for his and his family's continued subsistance. We do not understand a state of mind that permits plaintiff to think that only he himself is concerned."

While the total societal costs of traffic crashes have been estimated by others, the fraction of the losses which involve direct expenditure by state or municipal governments is not well defined.

The National Highway Traffic Safety Administration[1] has attempted to ascertain the societal costs of traffic accidents. Flora et

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[1] "Societal Costs of Motor Vehicle Accidents for Benefit-Cost Analysis: A Perspective of the Major Issues and Some Recent Findings." B. M. Faigin, Office of Program Planning, NHTSA, In Proceedings of the International Congress on Automotive Safety. July, 1975

al.[2] and Marsh et al.[3] attempted to estimate the costs to accident victims as a function of the injury severity. In the latter study, some attempt was made to determine who actually bore the various components of the cost. However, no previous study has attempted to identify governmental expenditures that result directly from traffic accidents.

The Michigan State Government incurs costs from traffic accidents in various ways. Portions of the client caseload in a variety of state-funded or partially-state-funded programs result from such accidents. Some examples of these programs are Aid to Dependent Children (ADC), Crippled Children's Fund, sick leave for state employees, and Medicaid. In addition, a portion of the case load in state courts results from traffic accidents. An indirect cost results from the necessity of assigning State Police officers to traffic control and accident investigation duties. If accidents could be substantially reduced, such personnel could be assigned to other duties. There may also be some indirect costs to the state in terms of lost tax revenues that would otherwise have been paid to the state, but were lost because of lowered income resulting from traffic accidents.

This study was concerned primarily with estimating the direct cost to the state of direct drains on tax revenues from traffic accidents. However, there are many other costs resulting from such accidents. Some of the costs accrue to other levels of government--local, city, county, or federal. Other components of the cost are borne by the general

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[2] "The Financial Consequences of Auto Accidents," J. D. Flora, J. Bailey, and J. O'Day, in Hit Lab Reports, Volume 5, number 10, June 1975.

[3] Financial Consequences of Serious Injury, J. C. Marsh et al. UM-HSRI-77-27, University of Michigan Highway Safety Research Institute, December, 1977.

public as insurance premiums for hospital/medical insurance, life insurance, or the most direct, automobile insurance. Thus, even with traffic accidents that do not impose a substantial direct cost to the state can still impose direct costs on the public. Some of the costs of traffic accidents are clearly borne by the individuals involved. In addition to the financial burden borne by individuals, there are often the intangible costs of pain and suffering of both the injured persons and their families.

Several components of direct costs to the State of Michigan resulting from traffic accidents have been identified. For some of these, data are available to provide reasonably good estimates of their magnitude. Unfortunately, for many components there is no direct source of data on the cost to the state, or the amount of the cost associated with traffic accidents cannot be segregated from other causes of that cost. For such sources indirect estimates of the cost to the state have been developed. While these are not definitive, they are the best available from the existing data.

Data Sources

A number of data sources have been utilized in deriving estimates of direct state costs for components where data do not permit direct estimates. A brief description of some of these data sources may be useful to orient the reader.

The National Crash Severity Study (NCSS) provides sampled data about vehicles and occupants involved in towaway crashes. The data came from seven investigation teams in various localities throughout the United States. The data set contains detailed information on injury severity, number of days hospitalized, days lost from work, etc. It is

restricted to accidents where at least one passenger car or light truck was towed away from the scene, and thus does not include accidents involving pedestrians, motorcycles, large trucks, or those (generally less-severe) accidents in which there were no vehicles towed away. A summary of these data is in NCSS Statistics.[4]

The Michigan accident data are recorded in a computerized data file containing information on all police-reported accidents in Michigan. The data for the calendar year 1979 has been used in this study. These data contain a wider scope of accidents than does the NCSS but less detail on individuals. In particular, little information on injuries or costs is available.

Several other data sources were utilized in deriving the cost estimates. Much information was obtained from telephone conservations and discussions with state employees. The data for Section 2.7 were obtained from the Michigan Department of Transportation and from 15 randomly selected county road commissions. Finally, personnel at The University of Michigan, Michigan State University, and Oakland University supplied HSRI with accident experience and cost data regarding auto insurance for state-owned vehicles. The sources of data for this study and a description of them are given in Table 1 below.

Organization of This Report

Section Two of this report details the various components of costs of accidents to the state. Each component cost is treated in a separate subsection that details the status of data available and gives the

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[4]NCSS Statistics: Passenger Cars, Leda L. Ricci (ed.), Highway Safety Research Institute, The University of Michigan, Report Number UM-HSRI-80-36, June 1980.

Table 1
Sources of Data For This Study

Source of Information	Description
NCSS	National Crash Severity Study contains detailed injury, hospitalization, and work loss data for a National Sample of passenger car accidents.
MAD	Michigan Accident Data constitutes a census of police-reported crashes in Michigan used to estimate injuries by occupant age, etc.
County Survey	Survey of 15 randomly selected County Road Commissions to ascertain road damage costs.
Universities	Automobile insurance costs were determined from three universities insured with private carriers.
State Agencies	Department of Social Services, Department of Transportation, Department of Labor, Attorney General's Office, and the Department of Education provided HSRI with information used to calculate various components of state cost.

methods and assumptions used to derive the estimates. In general we have aimed to estimate a lower bound conservatively. That is, the costs are generally at least as much as the estimate. Where possible, both upper and lower limits of the cost estimates are developed.

Section Three provides summaries of some case histories that have resulted in large costs to the State of Michigan for individual accident victims. It illustrates that a single injury can result in substantial cost to the state. Such cases are relatively rare, and it is difficult to determine precisely how many such cases exist. Nevertheless, the few cases discussed show the kinds of expenditures necessary.

Section Four discusses the indirect costs to the state resulting from traffic accidents, and provides estimates of these costs wherever possible.

Section Five summarizes the direct costs to the state and combines them into an estimated total annual cost. This section also classifies the components of direct state cost and provides information about the precision of the cost estimates.

Section Six presents examples of how this information on costs might be used in assessing the cost/benefit ratio for programs to reduce accidents or injuries. Separate examples are given for programs aimed at injury reduction and for programs aimed at general accident reduction, since the benefits from these types of programs would apply to different cost components.

2.0 COMPONENTS OF DIRECT STATE COST

Previous investigation[5] has revealed several components of direct cost to the State due to traffic accidents. They are:

(1) Care in state institutions for persons injured in crashes.

(2) Medicaid payments to persons injured in accidents.

(3) ADC payments for families in which the breadwinner was injured or killed in a traffic accident.

(4) Workers compensation and sick/disability leave payments for state employees hurt in traffic accidents.

(5) Litigation and judgment costs to the state highway department as a result of damage suits filed from traffic accidents.

(6) Special education costs and Crippled Children's Fund payments for children injured in traffic accidents.

(7) Cost to county or state road commissions for repair of damage caused by crashes.

(8) Automobile insurance for state-owned vehicles.

(9) Workers' Compensation for state employees.

The nine components of cost mentioned above are discussed in Sections 2.1 through 2.8. Information concerning data collection and estimates of the magnitude of these costs are given for each cost component. Indirect costs to the state associated with traffic accidents, such as loss of state income tax, are discussed briefly in Section 4.

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[5] Direct State Costs Resulting From Traffic Accidents, J. D. Flora et al., Highway Safety Research Institute, The University of Michigan, Interim Report Number UM-HSRI-80-74, December 1980.

2.1 Care in State Institutions

In this report "state institutions" refers to state-operated mental care facilities. Each year there are a number of accidents that result in substantial brain injury. Some of these persons require long-term care in a state mental institution. For example, a case is presented in Section Three in which a person received a severe brain injury and was hospitalized in Traverse State Hospital for twelve and one-half years. During this time, the cost of his care in Traverse State Hospital amounted to $183,212, 90% of which was paid from state money. As this example illustrates, such persons can incur substantial costs paid directly by the state.

It is very difficult to estimate how many such cases there are each year. Most such hospitals are not able to readily identify patients as coming as a result of a traffic accident. Such patients have to be identified by inspection of individual records. Even in this case, these records may not note that a person was institutionalized as a result of a traffic accident, because there would typically have been treatment in other hospitals intervening between the accident and admission to a state mental hospital. In addition, accident victims who would wind up in state mental institutions would typically be those who received a brain injury that resulted in some sort of violent or dangerous behavior. Patients who were brain injured and capable of only limited performance are more likely to be cared for in nursing homes, the cost to the state being absorbed in Medicaid.

In estimating the number of brain-injured accident victims in Michigan per year, we turn to the NCSS. There were 74 concussions of severity level AIS-4 (Serious) and 91 concussions of severity level

AIS-5 (Critical) in the 27-month study. The population covered by the NCSS was about 2% of the U.S. population, while Michigan contains about 5% of the U.S. population. Converting this to an annual estimate for Michigan, then results in a factor of

$$50 \times 12/27 \times 0.05 = 1.11$$

Applying this to the previous numbers results in an estimated 82 AIS-4 and 101 AIS-5 brain injuries in Michigan per year. Many of these persons die from the injuries. In the NCSS, 7.4% of the persons with AIS-4 and 56.6% of those with AIS-5 injuries died. Applying these factors results in the estimates that about 75 AIS-4 concussion survivors and about 44 AIS-5 concussion survivors would occur in Michigan annually. Nearly all of these persons would experience both a long recovery time and permanent disability. Marsh et al.[7] found examples of permanent loss of fine motor coordination, loss of balance, or permanent speech slurring among persons with AIS-4 or AIS-5 brain injuries--even in persons who were able to resume nearly normal activities.

We have contacted the directors or clinical personnel at each of 15 state mental care facilities. Most could not identify a single patient who was there as the result of traffic accident injuries. The exception to this was the Regional Psychiatric Hospital at Kalamazoo where an estimated 10 to 12 persons in this category are continually in residence. The Kalamazoo spokesman stated that the length of stay there was typically two to four years. Costs per patient at Kalamazoo are

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[6] The Abbreviated Injury Scale, American Association for Automotive Medicine (1980 Revision). 1980.

[7] Financial Consequences of Serious Injury, Marsh et al., December 1977.

given as from $75.00 to $159.00 per day, depending on the degree of care necessary. We will use $100.00 per day for computing total costs here. Twelve patients at $100.00 per day thus incur a cost to the state of about $438,000 per year, and this amount will be used in the summary costs presented in this report.

2.2 State Costs for Medicaid for Treatment of Accident Injuries

A large component of the direct cost to the state due to traffic accidents is Medicaid payments for treatment of crash victims. Medicaid payments are made for accident victims treated and convalescing in three types of hospitals:

(1) General hospitals

(2) Nursing homes

(3) City-county institutions

There are approximately 225 general hospitals in Michigan. About 200 of these are privately owned; the remainder are owned by city, county, or state government.

Privately owned general hospitals receive revenue from three major sources: (1) private insurance (i.e., Blue Cross or Blue Shield); (2) Medicare or Medicaid; and (3) patients. Since health insurance is very widespread, the patients, on the average, pay less than 10% of their hospital bill directly.

To estimate direct costs to the state, one needs to examine hospital revenues obtained from Medicaid, which receives 49% of its funds from the state, while the other 51% comes from the federal government. It is necessary to identify the people insured under

Medicaid who are in the hospitals as a result of traffic accidents, and then to tabulate their medical costs.

Government-owned general hospitals and city-county institutions have an additional source of revenue, namely, the branch of government that owns them (e.g., U of M hospital in Ann Arbor receives revenue from patients, health insurance, Medicare and Medicaid, and the State of Michigan). In some city-county institutions there is a revenue-sharing program, where the local government finances much of the hospital's costs, and the state finances the remainder not covered by private insurance or patients.

Nursing homes are, in general, privately owned, and are funded by the same sources as hospitals. However, Medicare and Medicaid pay a considerably greater proportion of nursing home billings than for hospitals. If the patients in the nursing homes due to traffic accidents can be identified, then an exact cost figure can be obtained from Medicaid.

People insured by Medicaid who are receiving payments due to traffic accidents can be identified. However, we have had some difficulty in translating the computerized Medicaid information from the Department of Social Services. At the time of writing this report, the Department of Social Services is writing a program intended to provide these data, but this may still take some time to complete. In the absence of these primary data, estimates of Medicaid costs may be arrived at as follows.

According to the Michigan Accident File (MAF) there were 1859 fatalities and 976,753 persons involved in crashes in 1979.

The following statistics were obtained from the National Crash Severity Study (NCSS) data file:

(1) 4.6% of all occupants were hospitalized at least overnight. Assuming that this figure applies to Michigan accidents,[8] an expected (976,753) (.046) = 44,931 occupants per year would need to be hospitalized at least overnight as a result of a crash.

(2) 16.9% of all occupants were treated at a hospital and released, i.e., they did not need to stay overnight. Assuming this figure applies to Michigan, an expected 165,071 = (976,753) (0.169) occupants per year would be treated and released.

(3) The average length of stay in the hospital <u>given that an occupant had to be hospitalized overnight</u> was 9.85 days. Occupants who were released spent one day in the hospital. The average length of hospital stay for people who died was 0.72 days. We will assume that these figures apply to Michigan accidents in the cost estimates that follow.

The following statistics were obtained from Robert Irwin, a spokesman for the University of Michigan hospital:

(1) In a sample of 18 general hospitals in Southeastern Michigan in 1979, the average cost per day to patients that were

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[8]The fatal traffic accident rate for Michigan in the period under study was about 3.0 fatalities per hundred million vehicle miles, which may be compared with a national average of 3.4. Since these are similar, the extrapolation of the distributions of the NCSS (national) data to the Michigan population seems justified. In addition, one of the seven sites used in the NCSS program was located in Michigan (in Washtenaw and Lenawee Counties), so that some of the NCSS distributions are based on the same accidents as are found in the Michigan accident data.

hospitalized was $354.17. This figure will be used to estimate medical costs of occupants who eventually died and non-fatal occupants requiring overnight hospitalization.

(2) For people who are treated and released such figures are unavailable. We will use Irwin's recommendation of $100 per day.

Let C_1 = the total annual medical care cost for people requiring overnight hospitalization due to a traffic accident. An estimate of C_1 would be (Number requiring hospitalization) x (Average hospital stay) x (Average daily hospital cost)

Inserting the appropriate numbers given above into this formula we obtain:

$$C_1 = (44,931)\,(9.85)\,(\$354.17) = \$156,745,141$$

Let C_2 = the total annual medical care cost for people that were treated and released due to a traffic accident.

$$C_2 = (165,071)\,(1)\,(\$100.00) = \$16,507,100$$

Let C_3 = the total annual medical care cost for people who died as a result of a traffic accident.

$$C_3 = (1,859)\,(0.72)\,(\$354.17) = \$618,898$$

Let TC = the total annual medical care cost for all people who were injured in traffic accidents in 1979.

Clearly, $TC = C_1 + C_2 + C_3 = \$173,699,290$

We need to determine the proportion of TC that Medicaid finances. To estimate this fraction we will utilize the following figures from The Health Care Financing Review, Summer 1980.[9] These data were

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[9] "National Health Expenditures, 1979." R. M. Gibson. Health Care Financing Review, Volume 2, pp. 1-36, Summer 1980.

interpreted by Richard Lichtenstein, Assistant Professor of Medical Care Organization in the School of Public Health at the University of Michigan.

(1) In 1979, Americans spent 188.6 billion dollars on health care.

(2) In 1979, Medicaid expenditures totalled 21.7 billion dollars.

Combining these figures we conclude that 11.51% = (21.7/188.6) x 100 of all health care expenditures in the U.S. in 1979 were financed by Medicaid. Lichtenstein believes that this figure applies to Michigan, and this leads directly to an estimate of total payments by Medicaid to people injured in traffic accidents, which we will denote by MTOT. An estimate of MTOT is:

$$MTOT = (.1151)(TC) = (.1151)(\$173,699,290) = \$19,992,788$$

As mentioned above, Medicaid receives 49% of its funds from the State of Michigan. Utilizing this figure leads to an estimate of the direct cost to the state due to Medicaid payments to accident victims, which we will denote as MSTATE. An estimate of MSTATE is:

$$MSTATE = (.49)(MTOT) = (.49)(\$19,992,788) = \$9,796,466$$

We will denote this estimate of MSTATE as $MUSTATE_1$ for reasons that will become clear later.

The estimate above should be used with caution, because it may overestimate the true value of MSTATE. The percentages of occupants who were hospitalized overnight and treated and released may be biased, since all occupants in the NCSS data file were involved in crashes where at least one vehicle had to be towed away from the scene. Since crashes where all vehicles could be driven away from the scene were excluded,

the crashes in the NCSS represent a sample of accidents severe than the entire population of accidents. The esti occupants hospitalized overnight is probably greater number. Also, the estimated average length of hospital greater than the actual average length. Note, however, tha cost per hospital day used in the cost estimates above pertained to a sample of hospitals where all illnesses were considered. The average cost per hospital day for people injured in traffic accidents is probably greater than $354.17, the average cost for all illnesses. Furthermore, medical care costs incurred after the patient has left the hospital have been excluded from the above calculations.

In summary, the actual value of MSTATE is probably somewhat less than the estimated 9.8 million dollars. However, we can use this figure as an upper-bound for MSTATE. To increase our knowledge of the magnitude of this cost, it is useful to derive an estimate that could serve as a lower bound for MSTATE.

To obtain a lower bound for MSTATE, we will consider the medical costs of accident victims who were in vehicles that were towed away from the scene of an accident. The medical costs of accident victims who were in vehicles that were not towed away will be excluded from the calculations. Assuming that non-towaway crash victims do not receive Medicaid payments, a lower bound for MSTATE may be arrived at as follows.

According to the MAF, there were 254,924 occupants of vehicles that were towed away from the scene of an accident in 1979. There were 1,859 fatalities.

The following statistics were obtained from the NCSS data file:

(1) 5.6% of all occupants of towed vehicles were hospitalized at least overnight. Assuming that this figure applies to Michigan,[10] an expected 14,276 = (254,924) (.056) occupants of towed vehicles would be hospitalized overnight.

(2) 20.7% of all occupants of towed vehicles were treated and released. Assuming that this figure applies to Michigan, an expected 52,769 = (254,924) (.207) occupants of towed vehicles would be treated and released.

(3) The average hospital stay of occupants of towed vehicles, given that they were hospitalized overnight, was 9.92 days.

We will denote the total annual medical care costs for people hospitalized overnight, treated and released, and fatalities as CL_1, CL_2, and CL_3, respectively. Estimates of CL_1, CL_2, and CL_3 may be obtained by using the formula:

Total Annual Cost = (Number Requiring Hospitalization)
x (Average Hospital Stay)
x (Average Daily Hospital Cost)

CL_1 = (14,276) (9.92) ($354.17) = $50,156,819

CL_2 = (52,769) (1.00) ($100.00) = $ 5,276,900

$CL_3 = C_3$ = (1,859) (0.72) ($354.17) = $618,898

Let TLC = a lower bound estimate for the total annual medical care cost for all people that were injured in traffic accidents in 1979.

Clearly, $TLC = CL_1 + CL_2 + CL_3$ = $56,052,617

Assuming as before that 11.51% of all medical care costs are financed by Medicaid, this leads to a lower-bound estimate of total payments by Medicaid to people injured in traffic accidents. We will

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[10]See footnote on page 16.

denote that as MLTOT. The state's share of these expenditures ($MLSTATE_1$) is (.49) (MLTOT). Using the figures above, we obtain:

$$MLTOT = (.1151)\ (\$56,052,617) = \$6,451,656$$

$$MLSTATE_1 = (.49)\ (\$6,451,656) = \$3,161,311$$

To summarize, by using information about the number of occupants, average length of hospital stay, and average hospital cost per day, we estimate that the direct cost to the State of Michigan for Medicaid payments to accident victims is between 3.1 (MLSTATE) and 9.8 (MUSTATE) million dollars as computed above.

There are other methods that can be used to derive upper and lower bounds for MSTATE.

One method is to classify occupants injured in a crash by their accident injury severity (AIS), estimate the average medical care costs for injured occupants at every AIS-level, and then tabulate total medical costs.

The method described above requires estimates of the average medical costs for each AIS-level, as well as the number of people with each injury severity.

To obtain an upper bound for MSTATE, we can use the MAF to obtain the total number of occupants in Michigan traffic accidents (976,753), and then use the AIS distribution observed in the NCSS to estimate the number of occupants with each AIS. The AIS distribution observed in the NCSS, and the expected number of Michigan occupants with each AIS-level is shown in Table 2 below.

The figures in the expected number of Michigan occupants column were computed by taking the total number of occupants (976,753), multiplying by the number in the percent column, then dividing by 100.

Table 2
NCSS AIS Distribution and Expected
Number of Michigan Occupants at each AIS-Level

Injury Severity (AIS)	N	%	Expected Number of Michigan Occupants
1-Minor	17,734	12.6	123,071
2-Moderate	4,107	2.9	28,326
3-Severe	2,028	1.4	13,675
4-Serious	547	0.4	3,907
5-Critical	383	0.3	2,930
Not Injured/Unknown	115,874	82.4	804,844
TOTAL	140,673	100.0	976,753

Several studies conducted in the past decade have aimed at estimating the average medical costs of individuals hurt in traffic accidents. We will use the results of two such studies to estimate average medical costs of crash victims at each AIS-level. These studies will lead to three upper-bound and three lower-bound estimates of MSTATE.

In a study conducted by the Department of Transportation (DOT) in 1975, estimates of average medical costs for each AIS-level were computed by referencing data concerning average length of hospital stay and average cost per hospital day. The design and results of this study are summarized in 1975 Societal Costs of Motor Vehicle Accidents by B.M. Faigin, where the average medical costs of individuals hurt in traffic accidents are estimated for each AIS-level.

In a study conducted by HSRI, during the period of December, 1967 through December, 1974, a sample of occupants was drawn from a population of Washtenaw County occupants who had sustained injuries due to a traffic accident. The sampled occupants were subsequently

interviewed and their AIS and medical costs obtained. The results are summarized in Financial Consequences of Serious Injury by J.C. Marsh, R.J. Kaplan, and S.M. Kornfield. The mean as well as the median medical costs for individuals hurt in traffic accidents were estimated for each AIS-level.

The sample sizes within each AIS-level in the HSRI study were rather small and generally were between ten and twenty occupants. Extreme cases where medical costs were very high were included in the sample. For example, one individual with an AIS-5 level injury incurred medical costs totalling $212,500. Since the mean is very sensitive to extreme values, especially when the sample size is small, the average medical costs computed in this study may overestimate the true mean medical costs at each AIS-level. With this in mind, both the mean and median costs from this study will be used to derive upper and lower bounds for MSTATE.

The mean and median costs from the HSRI study, as well as the average medical costs computed in the DOT study, are shown in Table 3 below. All costs in the table are in 1975 dollars.

Table 3
Average Medical Costs at each AIS-Level
in 1975 Dollars

AIS	Mean HSRI Study	Median HSRI Study	Mean DOT Study
One	$117	$38	$100
Two	$850	$636	$615
Three	$4,424	$3,849	$1,620
Four	$13,925	$10,492	$7,450
Five	$40,493	$13,294	$17,345

We need to convert the figures above to 1979 dollars. In the Statistical Abstract of the United States 1980,[11] the annual Medical Care Price Index (MCPI) is given with 1967 = 100.

For 1975, the MCPI was 168.6, while in 1979 the MCPI rose to 239.7. Using these figures, the percent increase in medical costs from 1975 through 1979 can be computed as follows:

$$\text{Percent Increase} = ((239.7 - 168.6) / 168.6) \times 100 = 42.2$$

Thus, medical care prices increased 42.2% during the period from 1975 through 1979. To convert 1975 dollars to 1979 dollars we need to multiply the 1975 figures by 1.422. The average and median medical costs from the HSRI study, as well as the average medical costs from the DOT study in 1979 dollars, are shown in Table 4 below.

Table 4
Average Medical Costs at each AIS-Level
in 1979 Dollars

AIS	Mean HSRI Study	Median HSRI Study	Mean DOT Study
One	$166	$54	$142
Two	$1,209	$904	$875
Three	$6,291	$5,473	$2,304
Four	$19,801	$14,920	$10,594
Five	$57,581	$18,904	$24,665

By combining the information contained in Tables 3 and 4 above, three upper-bound estimates of MSTATE can be computed. These will be denoted $MUSTATE_2$, $MUSTATE_3$, and $MUSTATE_4$, respectively.

[11] U. S. Bureau of the Census, Statistical Abstract of the United States 1980 (101st Edition), Washington, D.C., 1980.

Total medical costs at each AIS-level based on the mean costs of the HSRI study are computed in Table 5 below.

Table 5
Total Medical Costs at each AIS-Level
Based on the Mean Costs in HSRI Study

AIS	Number of Occupants	Average Medical Cost	Total Medical Cost
One	123,071	$166	$20,429,786
Two	28,326	$1,209	$34,246,134
Three	13,675	$6,291	$86,029,425
Four	3,907	$19,801	$77,362,507
Five	2,930	$57,581	$168,712,330

Summing the figures in the total medical cost column yields $386,780,182 as an estimate of the total medical costs incurred by individuals hurt in traffic accidents in Michigan.

Assuming as before that Medicaid finances 11.51% of all medical expenses, we obtain $44,518,399 = (.1151) ($386,780,182) as an estimate of the total Medicaid expenditures for people injured in traffic accidents. Since 49% of this is state money, we obtain $MUSTATE_2$ = $21,814,016 as an upper-bound on MSTATE.

Total medical costs at each AIS-level based on the median costs of the HSRI study are computed in Table 6 below.

Summing the figures in the total medical cost column yields $220,776,973 as an estimate of the total medical costs incurred by individuals hurt in traffic accidents.

An estimate of total Medicaid expenditures as well as the calculation of $MUSTATE_3$ is shown below.

$$\text{Medicaid(TOTAL)} = (.1151)\ (\$220,776,973) = \$25,411,430$$

Table 6
Total Medical Costs at each AIS-Level
Based on the Median Costs in HSRI Study

AIS	Number of Occupants	Average Medical Cost	Total Medical Cost
One	123,071	$54	$6,645,834
Two	28,326	$904	$25,606,704
Three	13,675	$5,473	$74,843,275
Four	3,907	$14,920	$58,292,440
Five	2,930	$18,904	$55,388,720

$$\text{Medicaid(STATE)} = \text{MUSTATE}_3 = (.49)\,(\$25,411,430) = \$12,451,601$$

Total medical costs at each AIS-level based on the mean costs computed in the DOT study are computed in Table 7 below.

Table 7
Total Medical Costs at each AIS-Level
Based on the Mean Costs in DOT Study

AIS	Number of Occupants	Average Medical Cost	Total Medical Cost
One	123,071	$142	$17,776,082
Two	28,326	$875	$24,785,250
Three	13,675	$2,304	$31,507,200
Four	3,907	$10,594	$41,390,758
Five	2,930	$24,665	$72,268,450

Summing the figures in the total medical cost column yields $187,427,740 as an estimate of the total medical costs incurred by individuals hurt in crashes.

An estimate of total Medicaid expenditures as well as the calculation of MUSTATE_4 is shown below.

$$\text{Medicaid(TOTAL)} = (.1151)\,(\$187,427,740) = \$21,572,933$$

$$\text{Medicaid(STATE)} = \text{MUSTATE}_4 = (.49)\,(\$21,572,933) = \$10,570,737$$

The average medical costs used to derive $MUSTATE_2$, $MUSTATE_3$, and $MUSTATE_4$ may also be used to obtain three lower-bound estimates of MSTATE which we will denote as $MLSTATE_2$, $MLSTATE_3$, and $MLSTATE_4$.

To obtain lower bounds for MSTATE we will consider the medical expenses of occupants in vehicles that were towed, and exclude the costs incurred by other accident victims. To estimate the total number of occupants in towed vehicles at each AIS level, we can use the MAF to obtain the total number of towed-vehicle occupants (254,924), and apply this to the AIS distribution for towed-vehicle occupants observed in the NCSS. The AIS distribution from the NCSS and the expected number of Michigan occupants of towed vehicles at each AIS level is shown in Table 8 below.

Table 8
NCSS AIS Distribution for Towed-Vehicle Occupants

AIS	N	%	Expected Number of Towed-Vehicle Occupants
One	16,159	15.2	38,748
Two	3,749	3.5	8,922
Three	1,853	1.7	4,334
Four	488	0.5	1,275
Five	346	0.3	765
Not Injured/Unknown	83,526	78.8	200,880
TOTAL	106,121	100.0	254,924

By combining the expected number of towed-vehicle occupants computed above, with the medical cost estimates from Table 4, three lower-bound estimates of MSTATE may be obtained.

Conservative estimates of total medical costs at each AIS-level based on the mean costs from the HSRI study are computed in Table 9 below.

Table 9
Total Medical Costs for Towed-Vehicle Occupants
Based on the Mean Costs in HSRI Study

AIS	Number of Occupants	Average Medical Cost	Total Medical Cost
One	38,748	$166	$6,432,168
Two	8,922	$1,209	$10,786,698
Three	4,334	$6,291	$27,265,194
Four	1,275	$19,801	$25,246,275
Five	765	$57,581	$44,049,465

Summing the total medical cost figures yields $113,779,800 as a conservative estimate of total medical costs incurred by crash victims.

A lower-bound estimate of total Medicaid expenditures for crash victims, as well as the calculation of $MLSTATE_2$ is shown below.

$$\text{Medicaid(TOTAL)} = (.1151)\,(\$113,779,800) = \$13,096,055$$

$$\text{Medicaid(STATE)} = MLSTATE_2 = (.49)\,(\$13,096,055) = \$6,417,067$$

Conservative estimates of total medical costs at each AIS, based on the median costs from the HSRI study, are computed in Table 10 below.

A conservative estimate of total medical costs incurred by crash victims is thus $67,362,422. Total Medicaid expenditures as well as the calculation of $MLSTATE_3$ are shown below.

$$\text{Medicaid(TOTAL)} = (.1151)\,(\$67,362,422) = \$7,753,415$$

$$\text{Medicaid(STATE)} = MLSTATE_3 = (.49)\,(\$7,753,415) = \$3,799,173$$

Conservative estimates of total medical costs at each AIS, based on the mean medical costs in the DOT study, are computed in Table 11 below.

Table 10
Total Medical Costs for Towed-Vehicle Occupants
Based on the Median Costs in HSRI Study

AIS	Number of Occupants	Average Medical Cost	Total Medical Cost
One	38,748	$54	$2,092,392
Two	8,922	$904	$8,065,488
Three	4,334	$5,473	$23,719,982
Four	1,275	$14,920	$19,023,000
Five	765	$18,904	$14,461,560

Table 11
Total Medical Costs for Towed-Vehicle Occupants
Based on the Mean Costs in DOT Study

AIS	Number of Occupants	Average Medical Cost	Total Medical Cost
One	38,748	$142	$17,776,082
Two	8,922	$875	$24,785,250
Three	4,334	$2,304	$31,507,200
Four	1,275	$10,594	$41,390,758
Five	765	$24,665	$72,268,450

A conservative estimate of total medical costs incurred by crash victims is thus $55,670,577. Total Medicaid expenditures as well as the calculation of $MLSTATE_4$ are shown below.

$$\text{Medicaid(TOTAL)} = (.1151)\,(\$55,670,577) = \$6,407,683$$

$$\text{Medicaid(STATE)} = MLSTATE_4 = (.49)\,(\$6,407,683) = \$3,139,765$$

To summarize, we have obtained four lower-bound and four upper-bound estimates of the direct cost to the state due to Medicaid payments to accident victims. These estimates are shown in Table 12 below.

It is desirable to summarize these lower and upper-bound estimates. We need a method of obtaining a point estimate of the upper bound of

Table 12
Lower- and Upper-Bound Estimates of MSTATE

Method of Estimation	Lower Bound Estimate	Upper Bound Estimate
Proportions	$3,161,311	$9,796,466
Mean (HSRI)	$6,417,067	$21,814,016
Median (HSRI)	$3,799,173	$12,451,601
Mean (DOT)	$3,139,765	$10,570,737

MSTATE, the lower bound of MSTATE, as well as a point estimate of MSTATE itself. One such method would be to take the mean of the four lower and upper-bound figures as our final estimates of the lower-and upper-bounds of MSTATE. We will denote these as MLSTATE and MUSTATE. A point estimate of MSTATE would be the midpoint of the resulting interval. Performing these calculations we obtain:

MLSTATE = $4,129,329

MUSTATE = $13,658,205

MSTATE = $8,893,767

Thus, the direct cost to the State of Michigan due to Medicaid payments to crash victims is estimated to be between 4.1 million and 13.7 million dollars. The midpoint of this interval is $8,893,767, which is our best estimate of MSTATE.

When they become available, the data on Medicaid claims resulting from automobile accidents will provide a better, almost definitive, figure for this cost. Some uncertainty may remain from missing data on cause of injury. However, these data will be capable of providing estimates by age and by type of provider. Thus they will have the advantage of additional detail as well as additional accuracy. Medicaid costs estimated from these data may be larger than the estimate of

MSTATE given above, because medical costs for outpatients will be included, while the estimates derived above are based on hospitalization costs only.

Medicaid payments constitute the largest component of direct state cost due to traffic accidents. This cost has been estimated here to be roughly 8.9 million dollars annually. This figure will be used in our summary presentation in Section Five.

2.3 Aid to Dependent Children

During the last year (1980), the State of Michigan spent approximately $770,000,000 on ADC payments to more than 200,000 families. In August 1980 the number of claims rose to 233,700 families--up from the July 1980 level of 230,881. Costs have climbed proportionately. It is possible that some of these payments resulted because the breadwinner was injured or killed in a traffic accident. Although a direct measure of this could not be obtained, a gross estimate may be arrived at as follows:

The 200,000 families are assumed to have one licensed driver each, and these drivers are assumed to have the average statewide accident rate per year. This would result in

787,860/6,250,000 = 0.126 accidents per driver per year, of which

223,400/787,860 = 0.2874 towaway accidents per crash.

From the NCSS, the proportion of occupants (of towed cars) injured at various levels of severity was:

Non-Fatal AIS-3+	0.033380
Non-Fatal AIS-4+	0.008228
Non-Fatal AIS-5	0.002050
Fatal	0.008640

There were 6.5% as many pedestrians injured in Michigan as occupants. Estimates of the number of heads of families on ADC that were injured in automobile accidents at various levels of severity result:

Number Families x (Crash/Family) x (Towaways/Crash) x (Injury/Towaway) x 1.065

= 200,000 x (0.126) x (0.2874) x (0.0334) x (1.065) = 258 (AIS -3)

= 200,000 x (0.126) x (0.2874) x (0.0082) x (1.065) = 63 (AIS-4)

= 200,000 x (0.126) x (0.2874) x (0.0021) x (1.065) = 16 (AIS-5)

= 200,000 x (0.126) x (0.2874) x (0.0086) x (1.076) = 66 (Fatals)

Thus these numbers represent estimates of how many breadwinners would be expected to receive a traffic injury per year. Estimated time lost by injury is:

AIS-3	3.6 months
AIS-4	12 months
AIS-5	63 months (includes some permanent)
AIS-6	Fatal--Permanent

This leads to an estimate of 66 families going on ADC in one year because the breadwinner was killed in a crash. An additional 16 would be expected because the breadwinner received a (non-fatal) AIS-5 injury, 63 because of an AIS-4 injury, giving a total of 145 families added to the ADC rolls each year as the result of traffic accidents.

This represents about 145/200,000 = 0.000725 of the total ADC costs each year, or $555,548. The fatalities and the AIS-5 injuries would cumulate.

A family that goes on ADC is reviewed every six months for eligibility. They may remain on until their financial situation improves or until there are no longer dependent children. A child is no

longer dependent after age 18. After age 16, to be considered dependent, a child must be a full-time student or working. Families may go on or off ADC as the surviving parent gets or loses a job. If we assume that the accident may occur at any time during this period, when the youngest child is up to age 18, then the average time from the accident until the youngest child reaches 18 would be nine years. As a result, if on the average, 66 families are added to the ADC rolls from traffic accident fatalities each year, and if these families stayed on continuously, there would be an average of 66 x 9 = 594 such families on ADC at any given time.

If a family is forced on ADC because of disability of the breadwinner resulting from a non-fatal accident, the family would remain on ADC until either the income resumes or until the youngest child is no longer dependent. For AIS-5 level injuries, the disability time is estimated to be an average of 6.5 years. Since in some cases the accident would occur when the youngest child is old enough so that fewer than 6.5 years would remain until he/she were no longer dependent, the average time would be somewhat less. If, as before, we assume that the accident happens randomly with a uniform distribution, then the average time on ADC would be about 5.33 years. (About 64% of the cases would occur with an average of 6.5 years, the remaining cases would average 3.25, giving $5.33 = 6.5 \times .64 + 3.25 \times .36$.) With the estimated 16 families per year from AIS-5 injuries, there would be an average of about 85 at any given year.

The average time lost for injuries at the AIS-4 level is about one year, so such injuries would not cumulate from year to year. Consequently, the total number of families on ADC because of traffic

accidents might be about 594 + 85 + 63 = 742 families out of the total of about 200,000. Thus, approximately four tenths of one percent of the families on ADC might be expected to be there because of an injury resulting from a traffic accident. Assuming that these families receive the average payment, the estimated annual cost would be $766,272,518 x 0.004 = $3,065,090. That is, in rough terms, a little over three million dollars per year might be spent on ADC payments as the result of breadwinners being injured in traffic accidents.

This figure was arrived at assuming that the risk of injury in a traffic accident applied to only one person per household. That is, it was assumed that there was only one breadwinner. If, in fact, both parents were breadwinners and if the injury to either would result in the family being forced on ADC, the above estimates would be doubled. While there are many families with two breadwinners, it does not seem likely that these would be in the situation that an injury to either would force the family on ADC. The number of families may be somewhat larger than estimated here, but would probably be closer to the current estimate than to the doubled amount. The $3 million will be considered the "best" estimate.

2.4 Costs Pertaining to State Employees

2.4.1 State Employees Sick Leave. An estimate of the sick leave cost to the State of Michigan caused by traffic accidents was arrived at as follows. From the National Crash Severity Study (NCSS) data we obtained the mean number of work days lost for occupants in passenger cars involved in towaway crashes. This was 1.15 work days. Using the Michigan State Police accident data from 1978, the number of occupants in passenger cars involved in towaway accidents in Michigan was found to

be 223,400. There were approximately 6,250,000 licensed drivers in Michigan and 68,000 state employees. Assume that state employees are all licensed drivers and that they have the same rate of involvement in towaway crashes as all drivers in Michigan. The estimate of 1.15 excludes persons with permanent disability, since they would not continue to draw sick leave. The work days lost for permanently disabled persons is about the same as for all other injured persons, although very few persons are permanently disabled. Inclusion of the permanently disabled would raise the mean to about 3.3 work days lost per occupant.

Let WD = Average work days lost/towaway crash (from NCSS).

NM = Number of occupants in passenger cars in towaway crashes.

SE = Number of state employees.

LD = Number of licensed drivers. From the data we have, estimates of these numbers are:

WD = 1.15,
NM = 223,400,
SE = 68,000, and
LD = 6,250,000.

Then the total number of work days lost by state employees involved in towaway crashes can be estimated as

$$SEWDL(TW) = (WD \times NM \times SE)/LD = 2795 \text{ work days per year.}$$

Also from the NCSS, the average number of work days lost in non-towaway crashes of passenger cars was found to be $UD(NTW) = 0.33$ days per occupant. The number of occupants in cars involved in non-towaway crashes in Michigan in 1978 was $NM(NTW) = 564,460$. Combining these leads to an estimate of work days lost by state employees because of passenger car accidents that were not severe enough to require towing as

$$SEWDL(NTW) = WD(NTW) \times NM(NTW) \times SE/LD = 2027 \text{ work days per year.}$$

In Michigan there were 6.1% as many persons injured in motorcycle crashes as occupants in passenger cars. In addition, there were 6.5% as many pedestrians injured as occupants of passenger cars. If one assumes that pedestrians and motorcyclists had the same number of work days lost from each accident (which is probably an underestimate, since injuries to pedestrians and motorcyclists tend to be more severe than injuries to occupants) then the total number of work days lost by state employees from automobile accidents (SEWDL) can be estimated as:

WDL (Towaways)	= 2795
WDL (Non-Towaways)	= 2027
WDL (Motorcyclists)	= 204
WDL (Pedestrians)	= 313
Total work days lost per year	= 5429

If the average salary for a State employee is $D per day, then the total cost for sick leave caused by traffic accidents can be estimated as SLC = $D x SEWDL. For example, if D =$75, then the total cost would be estimated to be $407,175 per year. A much larger proportion of motorcyclists and pedestrians are injured than are occupants of passenger cars. This comes about because a pedestrian accident is not an accident unless there is an injury. For example, 80% of occupants of passenger cars were listed as having no injury in the Michigan accident data from 1978, while 85% of motorcyclists and 96% of pedestrians were injured. Further, these injuries may be generally more severe than those sustained by occupants. Thus, the average number of work days lost may be larger for these categories.

State employees may also take sick leave because of sickness or injury to a member of their immediate family. As a consequence, if a

family member is injured in an automobile accident, this is likely to result in some loss of work days for the state employee. It seems difficult to estimate how large this loss would be, but perhaps the number of work days lost might be on the order of one-fourth to one-half as many as if the state employee were injured.

Suppose on the average each state employee has f immediate family members. Further, suppose that if a family member is injured this will result in a fraction p work days lost from work. Here p is a fraction less than one and represents the fraction of work days lost by a family member when another family member is injured. Then the estimate of the SEWDL could be modified by multiplying it by (1 + pf). That is, the increased time lost is estimated to be pf. The estimate of the total cost would be modified similarly by multiplying the SLC by (1 + pf). Currently neither p nor f is known even approximately. However, for illustration, suppose that p = 1/3 and f = 2. That is, suppose that on the average, each state employee has 2 immediate family members, and if one of them is injured in an automobile crash, the time lost to the state employee is one-third of the days lost by the family member (the work days that the family member would have lost if working). With these assumptions, the estimated cost of lost time because of automobile accidents involving state employees or their immediate family members becomes $678,625 per year.

Since half of unused sick leave is currently paid to the employee upon retirement, these costs might be discounted by one-half. That is, one-half of these costs would accrue to the state eventually anyway, although at a later date. A discounted value could be used, but the amount of the discount depends on the length of time in the future,

which would depend on the time to retirement of the employees injured. After October 1, 1980, new state employees are no longer entitled to this (terminal sick leave) benefit. It seems better to ignore the possible future payments of unused sick leave. Thus, $700,000 will be considered our best estimate of state employees' sick leave costs.

2.4.2 Workers Compensation. The cost to the state for workers compensation is the premium paid by state agencies for that insurance and the actual costs for state agencies that act as their own insurer. Part of this cost is associated with the risk of injury associated with traffic accidents resulting from job-related travel. In a study of claims settled in New York State in 1973 for Workers Compensation (Accident Facts 1977, p. 31) nine percent of claims were caused by automobile accidents. These claims amounted to twelve percent of the total dollar cost of the claims. It seems likely that automobile accidents might constitute a higher proportion of the claims for state employees that for all industry in general.

In Michigan, the average cost per claim for Workers' Compensation was $5,226. There were 1607 claims resulting from traffic accidents out of a total insured labor force of 3.9 million workers. Including employees at state universities, as well as state civil service workers, there are approximately 100,000 state employees. Assuming that these workers had the same rate of accident claims to all claims and that these claims were for the average dollar amount results in the following estimate of annual cost to the state from Workers' Compensation resulting from automobile accidents:

$$\frac{1.6\times10^{3}\ \text{Auto Claims}}{3.9\times10^{6}\ \text{Ins. workers}} \times 10^{5}\ \text{state workers} \times 5.226 \times 10^{3}\ \text{dollars/claim}$$

$$= \$214{,}000.$$

This figure is a reasonable estimate of the average annual cost. However, this figure would generally vary considerably from year to year because a very large claim results from a death, and the number of workers killed in job-related traffic accidents would be quite variable.

2.5 Litigation and Judgment Costs to the Michigan Department of Transportation

The State's total court costs consist of five components. They are:

(1) Costs of funding the Highway Negligence Division of the Department of Transportation

(2) Investigation costs

(3) Costs of hiring contract attorneys for specific court cases

(4) Actual dollars paid out in damages

(5) Staff support costs

The Highway Negligence Division consists of a group of lawyers (four or five) involved exclusively in traffic-related court cases. The direct cost of this office to the State (including salaries, overhead, and expenses) is estimated at $300,000 annually.

In many cases, investigators are sent to the scene of an accident. For example, if a vehicle hits a guardrail during a snowstorm and the driver claims the road was not salted, then the Investigations Section of the State Highway Department would send personnel to the scene of the accident to investigate the driver's claim. Total annual costs of investigations were approximately $150,000 prior to 1980, $210,000 in fiscal 1980, and $260,000 in fiscal 1981.

Contract attorney costs depend on the complexity of the court cases and have risen in recent years. Contract Attorney costs are summarized in Table 13 below:

Table 13
Contract Attorney Costs

Fiscal Year	Contract Attorney Costs
1975	80,000 - estimated
1976	81,500
1977	80,000 - estimated
1978	83,800
1979	156,800
1980	160,000 - estimated

The 1975 and 1977 estimates were obtained from Ronald Hoffmeister, a spokesman for the Michigan Department of Transportation.

An estimate for 1980 was obtained by utilizing data for the first 9 months of fiscal 1980. For the nine-month period ending June 30, 1980, the state spent 120,000 dollars for contract attorneys. Assuming the court cases against the state will not drastically change in magnitude and complexity, the highway department will have spent 40,000 dollars for contract attorneys during the last three months of fiscal 1980, and the total amount spent in fiscal 1980 will thus be 160,000 dollars, as shown in Table 12.

Staff support costs are incurred when engineers and other professionals are hired for specific court cases. According to Irene Mead, a spokesperson for the Department of Transportation, "Staff support costs are at least $350,000 per year."

The total litigation costs to the state is the sum of the Highway Negligence Division costs, investigation costs, contract attorney costs,

and staff support costs. Total litigation costs are summarized in Table 14.

Table 14

Litigation Costs

Fiscal Year	Total Litigation Costs
1975	$880,000 (Estimated)
1976	$881,500
1977	$880,000 (Estimated)
1978	$883,800
1979	$956,800
1980	$1,020,000 (Estimated)
1981	$1,070,000 (Estimated)

The figure for 1981 assumes that only investigation costs will change. Therefore, it will probably underestimate the litigation costs the state will incur during this fiscal year.

Judgment costs are a major component of direct state cost. They occur when the state is sued and loses. Judgment costs are highly variable and seem to be increasing more in proportion to the number of cases and the amount awarded than with inflation.

In the interim report,[12] judgment costs were estimated to be two million dollars for 1980. The actual judgment costs were $2,109,925. For the four-month period ending April 30, 1981, the state lost $1,088,894 in judgments. Assuming that judgment costs for the remainder of fiscal 1981 will not drastically change, the above figure can be multiplied by three to yield $3,266,682 as an estimate of the judgment costs the state will incur in fiscal 1981.

[12] Direct State Costs Resulting From Traffic Accidents, Flora et al., December 1980.

Judgment costs for the fiscal years 1975-1981 are summarized in Table 15.

Table 15

Judgment Costs

Fiscal Year	Judgment Costs
1975	$1,190,000
1976	$ 235,000
1977	$ 784,000
1978	$1,885,543
1979	$3,013,532
1980	$2,109,925
1981	$3,266,682 (Estimated)

The figures given in Table 15 need to be qualified. The judgment costs given to HSRI by the State Highway Department, excludes judgments against the state that are currently being appealed. If the Michigan Department of Transportation loses the appealed case, they may either appeal the case to a higher court or pay out the judgment.

Judgments against the Highway Department that have not been paid due to appeal by the state currently total $14,132,210. This figure includes the case of McKee vs. The State of Michigan, where the state has already lost a 5.6 million dollar judgment due to an accident in Wayne County.

The total court costs to the state (i.e., litigation plus judgment costs) are summarized in Table 16.

Thus the average annual state court cost was 2.7 million dollars during fiscal years 1975-1981, and 3.6 million over the last four fiscal years. Since court costs have increased significantly during the last

Table 16

Total Court Costs

Fiscal year	Total Court costs
1975	$ 2,070,000 (Estimated)
1976	$ 1,116,500
1977	$ 1,664,000
1978	$ 2,769,343
1979	$ 4,033,532
1980	$ 3,129.925 (Estimated)
1981	$ 4,336,682 (Estimated)
TOTAL	$19,119,932 (Estimated)
Mean	$ 2,731,426
Mean (1978-1981)	$ 3,576,370

four fiscal years, the 3.6 million dollar figure is probably a better estimate of annual court costs for the future. This latter figure will be used in our summary presentation.

2.6 Costs Due to Special Education and the Crippled Children's Fund

The Crippled Children's Fund, which is governed by the Michigan Department of Public Health, provides 20 million dollars in payments to families of crippled children each year. The Crippled Children's Fund receives revenue from two sources. They are:

(1) The State's general fund, which supplies 13.5 million dollars.

(2) Miscellaneous contributions totalling 6.5 million dollars per year.

The state's total special education costs consist of two components. They are:

(1) Transportation costs--some children receiving special education require specific means of transportation, e.g., vans equipped to transport children in wheelchairs.

(2) Classroom costs for teachers, supplies, and books.

The total classroom costs for the 12-month period ending September 30, 1979, were 44.8 million dollars, they consisted of the following components.

(1) Costs for children with learning disabilities totalling 36.8 million dollars.

(2) Expenses for physically impaired children totalling 8 million dollars.

The State's total special education costs for fiscal 1979 was 86.4 million dollars. The Department of Public Health and the Michigan Department of Education do not keep records identifying which children receive special education or crippled children's benefits due to injury in a traffic accident. In the absence of such data, estimates of these two components of direct state cost may be arrived at in the following manner.

Consider those persons who become quadriplegic or paraplegic as a result of a traffic accident that occurred prior to their eighteenth birthday. Since these people are permanently crippled, they are eligible for Crippled Children's Fund benefits and may require special education. Assuming that only quadriplegics and paraplegics collect such benefits as a result of a crash, conservative estimates of direct state costs due to special education and the CCF may be derived by estimating the number of child quadriplegics and paraplegics in Michigan

at any one time, and then tabulating their special education costs and Crippled Children's Fund benefits.

Estimation of the number of quadriplegics in Michigan traffic accidents. Two similar approaches can be used to estimate the number of quadriplegics resulting from traffic accidents in Michigan in a year. One approach is to take the surviving AIS-5 neck injuries estimated from the NCSS (11) times the ratio of missing data assumed in the NCSS (1.15) times the ratio of the time of NCSS data collection to one year (0.8) times the ratio of occupants in Michigan passenger car towaway occupants (254,924) to 62,026 (the number of occupants in NCSS).[13] This results in an expected forty-two quadriplegics per year.

A second approach is to take the estimate of Kraus et al.[14] of 650 cases per year in the United States, and multiply it by (8,875,083)/(203,235,298)--the ratio of Michigan population to the U.S. population. This results in an expected 28 quadriplegics per year in Michigan from in-car injuries. We will use the estimate of Kraus et al. to derive lower-bound estimates of direct state costs due to special education and the CCF, and then use the estimate obtained from the NCSS to derive upper-bound estimates. The midpoint of the resulting intervals will serve as our best estimate of these components of direct state cost.

In order to determine the number of children quadriplegics, we need the age distribution of occupants who became quadriplegics as a result of a traffic accident. Such data are not available. However, the

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[13] Cervical Injuries in Automobile Crashes, D. F. Huelke et al., Highway Safety Research Institute, The University of Michigan, Report Number UM-HSRI-80-40, May 1980.

[14] "Incidence of Traumatic Spinal Cord Lesions," J. F. Kraus et al. Presented at the Annual Meeting of the American Public Health Association, New Orleans, Louisiana, October 23, 1974.

Michigan Accident File contains information about occupants in vehicles where someone was incapacitated in a crash. These data are given in Table 17 below.

Table 17

Age Distribution of Occupants in Vehicles Where Someone was Incapacitated

Age (In Years)	N	Percent	Expected Number Quadriplegics Per Year
0-5	1,071	2.3	0.64
6-10	1,496	3.2	0.90
11-15	2,591	5.5	1.54
16	1,822	3.9	1.09
17	2,280	4.9	1.37
18 or Older	37,741	80.3	22.48
TOTAL	47,001	100.0	28.00

Assuming that the age distribution given above is similar to the distribution of quadriplegics, the expected number of quadriplegics per year, based on Kraus's estimate, was computed by taking the percent column and multiplying it by 28/100.

In summary, of the 28 new quadriplegics per year, approximately five will be less than 18 years of age. Since some of these quadriplegics require more than one year of special education and Crippled Children's Fund benefits, the number of child quadriplegics receiving such benefits would cumulate.

To estimate these costs, we need to determine the number of years of special education and CCF benefits that an injured child will need. Thus, we will assume that a child starts special education at age six

years and completes it at age 18, and that Crippled Children's Fund benefits begin when the child is injured and end when the child is 18 years of age. The number of CCF recipients at any one time for a given age group is the number of quadriplegics multiplied by the number of years they will receive benefits. The same calculation gives the number receiving special education at any one time. These calculations are shown in Tables 18 and 19 below.

Table 18

The Prevalence of Special Education Recipients

Age (In Years)	Expected Number Quadriplegics Per Year	Years of Special Education Needed	No. Receiving Special Education Any One Time
0-5	0.64	12	7.68
6-10	0.90	10	9.00
11-15	1.54	5	7.70
16	1.09	2	2.18
17	1.37	1	1.37
TOTAL	5	--	27.93

Thus, in any given year, an estimated 28 children quadriplegics are receiving special education due to a traffic accident, while 30 are receiving Crippled Children's Fund payments.

To estimate the total state cost, it is necessary to determine the average payment. As mentioned above, the CCF is funded at 20 million dollars annually. These payments go to approximately 13 thousand children. The average annual payment is thus $1,538 per child.

Table 19

The prevalence of Crippled Children's Fund (CCF) Recipients

Age (In Years)	Expected Number Quadriplegics Per Year	Years of CCF Benefits Needed	No. Receiving CCF Benefits at Any One Time
0-5	0.64	15.5	9.92
6-10	0.90	10.0	9.00
11-15	1.54	5.0	7.70
16	1.09	2.0	2.18
17	1.37	1.0	1.37
TOTAL	5	--	30.17

Assuming that each child quadriplegic receives the average payment, the total cost to the CCF is ($1,538) (30) = $46,140.

Total special education costs to the state consist of two components. They are:

(1) Transportation costs of $1,600 per student per year.

(2) Classroom costs that depend upon the nature of the disability.

Disabled children are divided up into two categories that determine the classroom costs of the individual. They are (1) children with learning disabilities, and (2) physically impaired children. While there may be some children with learning disabilities that resulted from traffic accidents, physical impairments are more common.

Quadriplegics and paraplegics would be considered physically impaired children and would incur transportation costs. The annual per pupil classroom cost for physically impaired children is $4,071. Thus, the total per pupil special education cost for quadriplegics and paraplegics is $5,671. These per pupil costs were obtained from the

Michigan Department of Education. We estimate, then, that the state spends $158,788 annually for special education of 28 quadriplegics who were injured in a traffic accident. To estimate these costs for paraplegics we need to determine the prevalence of child paraplegics. In a Northern California Incidence Study conducted by Kraus, paraplegics outnumbered quadriplegics 1.3 to 1.0. Assuming that this ratio applies to Michigan, and that the age distribution given in Table 17 applies to paraplegics, we obtain 36.4=28(1.3) as an estimate of the prevalence of child paraplegics originally injured in a crash. Thus, by multiplying quadriplegic costs by 1.3, we can obtain the total special education costs of child paraplegics. This leads to an estimate of $206,424. A lower-bound estimate of the direct cost to the state for special education of children hurt in a traffic accident is thus:

$$\$206,424 + \$158,788 = \$365,212.$$

A similar method can be used to estimate CCF payments to paraplegics. Assuming that each child paraplegic receives an average payment, we obtain $ 59,982 = ($46,140)(1.3) as an estimate of total CCF payments to child paraplegics. Summing the costs of paraplegics and quadriplegics leads to an estimated $106,122 in CCF payments to families of crippled children. However, not all of this is state money. The state supplies 13.5 million dollars to the CCF annually, while the other 6.5 million comes from miscellaneous contributions. Therefore, a lower-bound estimate of the direct state cost for CCF payments to families of crippled children hurt in crashes is (13.5/20.0)($106,122) = $71,632.

To obtain an upper-bound estimate of direct state costs due to these components, we will take the estimate of 42 quadriplegics obtained from the NCSS and apply it to the age distribution given in Table 17

above. This leads to an upper-bound estimate of the number of child quadriplegics that is shown in Table 20 below.

Table 20
Calculation of the Expected Number of Quadriplegics, Using NCSS Estimate

Age (In Years)	Percent of Occupants	Expected Number Quadriplegics Per Year
0-5	2.3	0.97
6-10	3.2	1.34
11-15	5.5	2.31
16	3.9	1.64
17	4.9	2.06
18 or Older	80.3	33.73
TOTAL	100.0	42.00

The numbers in the "Percent of Occupants" column represent the age distribution given in Table 17 above. The expected number of quadriplegics per year, based on the NCSS estimate, was computed by taking the numbers in the percent column and multiplying them by 42/100. We can use these figures to calculate the prevalence of children receiving special education and CCF payments. These calculations are shown in Tables 21 and 22 below.

Thus, there will be approximately eight new child quadriplegics per year, 42 child quadriplegics receiving special education at any one time, and 45 child quadriplegics receiving CCF benefits at any one time.

Assuming that each student incurs the average per pupil cost, we obtain $238,182 = (42) ($5,671) as an upper-bound estimate for special education costs of child quadriplegics who were originally hurt in traffic accidents. Since paraplegics outnumber quadriplegics 1.3 to

Table 21
Upper-Bound Estimates of the Prevalence
of Special Education Recipients

Age (In Years)	Expected Number Quadriplegics Per Year	Years of Special Education Needed	No. Receiving Special Education At Any One Time
0-5	0.97	12	11.64
6-10	1.34	10	13.40
11-15	2.31	5	11.55
16	1.64	2	3.28
17	2.06	1	2.06
TOTAL	8.32	--	41.93

Table 22
Upper-Bound Estimates of the Prevalence
of CCF Recipients

Age (In Years)	Expected Number Quadriplegics Per Year	Years of CCF Benefits Needed	No. Receiving CCF Benefits At Any One Time
0-5	0.97	15.5	15.04
6-10	1.34	10.0	13.40
11-15	2.31	5.0	11.55
16	1.64	2.0	3.28
17	2.06	1.0	2.06
TOTAL	8.32	--	45.33

1.0, we obtain $309,637 = ($238,182)(1.3) as an estimate of children paraplegic costs. An upper-bound estimate of the direct costs to the state due to special education for children hurt in traffic accidents is thus $547,819. Our lower-bound estimate was $365,212. The midpoint of this interval is $456,516 which will serve as our best estimate of special education costs.

Assuming that each child receives the average CCF payment of $1,538 annually, an upper-bound estimate for quadriplegics is $69,210 = (45) ($1,538). For paraplegics an upper-bound estimate is ($69,210) (1.3) = $89,973. The total cost to the CCF for payments to children who were accident victims is thus $159,183. The total cost to the state is: (13.5/20) ($159,183) = $103,469.

Thus, an upper-bound estimate of the state's share of CCF payments to accident victims is $103,469. Our lower-bound estimate is $71,632. The midpoint of these two figures is $87,551, which will serve as our best estimate of CCF costs.

In summary, the direct cost to the state due to special education is between $350,000 and $550,000, and the direct state cost due to CCF payments is between $70,000 and $100,000. We will use $450,000 as our best estimate of special education costs and $90,000 as our best estimate of CCF costs. These figures will be used in the summary in Section Five.

2.7 Cost to State and County Road Commissions

The Michigan Department of Transportation and all of the county road commissions in Michigan receive revenue from three sources. They are:

(1) The State gasoline tax

(2) The sales tax on gasoline

(3) The weight tax on license plates purchased by Michigan drivers

The gasoline tax is 11 cents per gallon. The license plate tax is directly proportional to the weight of the vehicle. Both the gasoline and license plate tax go directly to the Michigan Transportation Fund

and are distributed according to the following formula defined by Act 51 of Public Acts 1951:

(1) 34.3% of the revenue goes to county road commissions.
(2) 19% goes to city road commissions.
(3) 46.7% goes to MDOT and is distributed in the following manner:
(a) 82.2% to the state trunkline system.
(b) 17.8% for public transportation.

The sales tax is 4% of the cost of the gasoline purchased, and goes to the state's general fund. Act 51 controls the distribution of 75% of this revenue with 15% going to townships and 60% going to school aid. The remaining 25% stays in the general fund and is used for miscellaneous purposes including the Michigan Department of Transportation.

The previous discussion implies that the State of Michigan has total financial responsibility for the repair of highway damage caused by traffic accidents. To obtain an estimate of the direct cost to the State of Michigan due to traffic accidents, estimates of the expenditures of the Michigan Department of Transportation and all county and municipal road commissions (83 county road commissions exist) are required. Summing these figures will yield an estimate of the direct cost to the state.

Figures from the Michigan Department of Transportation indicate that the costs to Michigan for accident-related street repairs are substantial. For the 12 month period ending June 30, 1979, the State billed drivers $937,413 for damage to the state trunkline system (i.e., roads such as US-23, I-75, and M-59). Since a substantial portion of this money is recovered from private insurance companies, this figure

cannot be interpreted as the direct cost to the State Highway Department due to traffic accidents.

Since in some cases the driver is not considered to be at fault in the crash, the money collected from the insurance companies is somewhat less than the amount billed. Also, according to Carl Otto, a state highway department employee, "Approximately 40% of the cases are written off because the highway department cannot find the drivers within a reasonable period of time." This difference between the money collected and the amount billed is the direct cost to Michigan.

For the 12-month period ending June 30, 1979, the state highway department collected $637,948 from insurance companies. Therefore, the unreimbursed accident repair cost to the state highway department for that year was $299,465 (i.e., $937,413 minus $637,948). Note that this figure excludes expenditures for unreported crashes on the state trunkline system; e.g., if someone hits a guardrail on an interstate road and drives away from the scene, then the state cannot charge the damage to any driver. Modern safety features such as breakaway utility poles and crash cushions are often damaged so much that expensive repairs are necessary even though the striking vehicle can drive away from the scene. Since the highway department does not separately identify such occurrences, the above figure underestimates the direct costs to the state.

Other factors concerning the precision of this estimate should be noted. Major accidents have a substantial effect on both the amount charged and the money collected. For example, in fiscal 1968, an accident occurred which resulted in structural damage severe enough to necessitate building a new bridge, which cost the state $500,000. The

variance of the amount charged and the money collected will be quite large.

However, it is the variance of the difference between these two figures that is of concern. Since most of the money collected is for accidents that occurred in the same year, the amount charged and the money recovered from insurance companies will be positively correlated. This relationship implies that the variance of the direct cost to the Michigan Department of Transportation should be somewhat lower than the variability in the money collected and the amount billed. The direct cost to the Michigan Department of Transportation should not vary greatly from year to year. However, it would certainly be incorrect to assume that the variance is negligible.

With this in mind, figures pertaining to the six calendar years from 1974 through 1979 were obtained. These figures increase the precision of the cost estimate, and are summarized in Table 23 below.

Table 23
Costs to the Michigan Department of Transportation
for Repair of Damage Caused by Crashes

Year	Amount Billed	Amount Collected	Cost to Highway Department
1974	$ 566,284	$ 566,284	$ 27,923
1975	1,199,075	774,459	424,616
1976	980,388	698,257	282,131
1977	874,206	736,903	137,303
1978	821,466	633,891	187,575
1979	1,035,166	820,160	215,006
TOTAL	$5,477,125	$4,202,571	$1,274,554
MEAN	$ 912,854	$ 700,428	$ 212,426

The figures above have been rounded to the nearest dollar. The total row is the sum of the six calendar years, while the mean row is the average of the six yearly figures.

The average cost to the Michigan Department of Transportation for the six-year period ending December 31,1979, was $212,426. If we exclude 1974, the year of the oil embargo and subsequent energy crisis from the analysis, the average cost was $249,326. Due to the energy crisis, people drove less in 1974. The resulting low cost figure may be due in part to fewer miles being driven by Michigan drivers.

To estimate county unreimbursed road repair costs, a sample of county road commissions was undertaken. The sample was designed by defining three groups (strata) of counties based on 1970 population, and subsequently taking a simple random sample of counties within each strata. The three strata were defined as follows:

STRATUM 1: Wayne, Oakland, and Macomb counties. This stratum was declared a self-representing area, and all three of these counties were selected into the sample.

STRATUM 2: Counties with population greater than 100,000, excluding Wayne, Oakland, and Macomb counties. Fourteen Michigan counties were in this stratum, and three of these were selected into the sample. The sampling fraction was 3/14 in this stratum.

STRATUM 3: Counties with population less than 100,000. The remaining 66 Michigan counties were in this group, and nine of these were selected into the sample. Thus, the sampling fraction was 9/66 in Stratum 3.

The selected counties were:

STRATUM 1: Wayne, Oakland, Macomb

STRATUM 2: Berrien, Kent, St. Clair

STRATUM 3: Antrim, Branch, Clare, Crawford, Lapeer, Manistee, Newaygo, Presque Isle, Wexford

The results of this sample are given in the tables that follow.

Table 24

Stratum 1: Wayne, Oakland, and Macomb Counties

County	Unreimbursed Road Repair Cost
Wayne	$9,054*
Oakland	$66,079
Macomb	$13,315
TOTAL	$88,448

*This county gave us a conservative and educated estimate of their unreimbursed road repair costs.

Note that county unreimbursed road repair costs are not always positively correlated with population. For example, Macomb county's cost was greater than Wayne's, while Berrien county had the highest unreimbursed repair costs. However, the figure for Wayne county was an estimate, and the figure for Berrien county deserves closer examination. In 1980, a bridge collapsed on a Berrien county road when a passenger car carrying flammable materials caught fire while traversing the bridge. The bridge cost of repair was $260,000, and the county received only $20,000 from the driver's insurance company. Thus, an increment of $240,000 was added to Berrien County's cost due to a single accident. Since individual accidents with such costs occur almost once a year somewhere in Michigan, the $240,000 increment was included in the total.

Table 25

Stratum 2: Counties with Population Greater than 100,000

County	Unreimbursed Road Repair Cost
Berrien	$165,238
Kent	$7,125
St. Clair	$3,320
TOTAL	$175,683

Table 26

Stratum 3: Counties with Population Less than 100,000

County	Unreimbursed Road Repair Cost
Antrim	$0
Branch	$510
Clare	$813
Crawford	$1,150
Lapeer	Non response
Manistee	$1,000*
Newaygo	$142
Presque Isle	$0
Wexford	$5,000*
TOTAL	$8,615

*These counties gave us a conservative and educated estimate of their unreimbursed road repair costs.

As indicated in Tables 24 and 26, not all figures are exact. Also, every county official contacted stated that the actual unreimbursed road repair cost was at least twice as much as the figure given. This non-coverage is due to unreported crashes on county roads. In such cases, the county has no driver to charge for road damage. Unreimbursed costs

for unreported crashes are usually recorded in the same file as routine maintenance costs, and therefore cannot be separated from them.

With this in mind, two estimates of the annual county unreimbursed road repair costs will be derived. One estimate will be based on the actual data, while the other estimate will be based on the actual data multiplied by the non-coverage factor two.

Let CO = The total annual state cost due to unreimbursed road repairs on all county roads, based on the actual data.

Let CO* = 2(CO).

Let X_1 = The total unreimbursed road repair cost of sampled counties in Stratum 1.

Let X_2 = The total unreimbursed road repair cost of sample counties in Stratum 2.

Let X_3 = The total unreimbursed road repair cost of sampled counties in Stratum 3.

All three counties in Stratum 1 were included in the sample. Therefore, the sampling fraction was one. Fourteen Michigan counties belonged to Stratum 2, and three of these were selected into the sample. Thus, the sampling fraction was 3/14 in Stratum 2. The remaining sixty-six counties belonged to Stratum 3, and nine of these were included in the sample. Thus, the sampling fraction was 9/66 in Stratum 3.

To get an estimate of CO, we need to multiply the stratum totals by the multiplicative inverse of the sampling fraction in each stratum. Therefore, our estimate of CO from the sample would be:

$$CO = X_1 + (14/3)(X_2) + (66/9)(X_3)$$

This estimate is correct for Stratum 1 and Stratum 2. However, it is incorrect for Stratum 3, because Lapeer county did not respond. In

Survey Sampling by Leslie Kish,[15] the following solution is given to the problem in Stratum 3.

Kish proposes that a new sampling fraction can be obtained when there is nonresponse by multiplying the original sampling fraction (9/66) by the observed response rate (8/9). Thus, the new sampling fraction is 8/66, and we can obtain an estimate of the total cost in Stratum 3 by multiplying X_3 by 66/8. Therefore, the correct estimate of CO is:

$$CO = X_1 + (14/3)(X_2) + (66/8)(X_3)$$

From the tables above, we obtain:

$X_1 = \$28,448 \quad X_2 = \$175,683 \quad X_3 = \$8,615$

Therefore,

$$CO = \$28,448 + (14/3)(\$175,683) + (66/8)(8,615)$$

$$CO = \$1,023,987$$

$$CO^* = (2)(CO) = 2(\$1,023,987) = \$2,047,974$$

The annual direct state cost due to unreimbursed road repair on state trunkline roads was given above. This cost was $212,426 and will be denoted as ST.

There are also state costs incurred on local or municipal roads. However, hundreds and perhaps thousands of these road commissions exist. Sampling city road commissions would be costly and time consuming. Furthermore, according to the Twenty-Eighth Annual Progress Report for County Road Commissions, Incorporated Cities and Villages of Michigan,[16]

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[15] Survey Sampling, Leslie Kish. New York, John Wiley and Sons, 1965.

[16] County Road Commissions, Incorporated Cities and Villages of Michigan. 28th Annual Progress Report, Michigan Department of Transportation. Lansing, Michigan. 1978.

local roads comprise only 16.2% of all the road miles in Michigan, while the state trunkline and the county road system comprise the other 83.8%. We have an estimate for state and county roads, so we use these percentages to derive an estimate of the local road repair cost by assuming that unreimbursed road repair costs per mile are the same for local roads as they are for state and county roads. That is, we can multiply ST + CO by (100/83.8).

Let TC = The total annual state cost due to unreimbursed road repairs on all Michigan roads based on CO.

Let TC* = The same cost based on CO*.

Then,

$$TC = (\$212,426 + \$1,023,987)\ (100/83.8)$$

$$TC = \$1,475,433$$

$$TC^* = (\$212,426 + \$2,047,974)\ (100/83.8)$$

$$TC^* = \$2,697,375$$

The estimate TC is extremely conservative, while the estimate TC*, although partly based on extrapolation, is probably closer to the truth. We will use $2.7 million in the summary presentation.

2.8 Automobile Insurance Costs for State Vehicles

The State of Michigan purchases automobile insurance for its fleet of cars, trucks, buses, and miscellaneous vehicles. This includes vehicles at all state universities that participate. Currently, three universities, Michigan State University, The University of Michigan, and Oakland University, purchase their own insurance. Their insurance costs are summarized below:

Oakland University purchases both liability and collision insurance. They carry $500 deductible policies. Their approximate premium is currently $14,000 per year. Information on losses under the deductible was not readily available.

The University of Michigan purchases liability insurance (currently from INA) and acts as its own insurer for physical damage. The costs for the past two years are summarized in Table 27 below:

Table 27
University of Michigan Insurance Costs

Year	Liability Premium	Physical Damage	Total
1978-1979	$58,984	$63,917	$122,901
1979-1980	$85,652	$78,056	$163,708

The totals represent costs for approximately 500-600 vehicles, including cars, trucks, and buses ($145 per vehicle).

Michigan State University purchases liability and acts as its own insurer for physical damage. Their liability premiums are summarized in Table 28.

Table 28
Michigan State University
Insurance Costs

Year	Liability Premium
1978-1979	$61,005
1979-1980	$90,200
1980-1981	$112,000

This is for comprehensive liability with $26,000,000 limit total. It covers 19 buses, 135 trucks, and about 600 cars, plus some trailers, or $145 per vehicle.

We were not able to obtain a reliable estimate for the physical damage repair costs from MSU. The motor pool officials estimated "about $20,000," but it was not clear whether this represented cost recharged to departments or cost incurred directly by the motor pool, i.e., not rechargeable to a specific source. Department-owned cars may be fixed off campus. No information on that source could be found. If a motor pool car is damaged, the first $500 is charged to the department using the car at the time of the crash (which may or may not involve State funds directly).

Table 29 gives the premium cost, the approximate number of vehicles, the proportion of cars, trucks, or other, and the premium per vehicle for the State of Michigan's fleet of vehicles during the last five years. These figures pertain to all State agencies except the three universities mentioned above.

Total cost of insurance premiums was available for the earlier years back to the 1970-71 year. These were:

Year	Premium
70-71	$323,772
71-72	$955,814
72-73	$340,104
73-74	$402,008
	(If limited collision coverage was excluded, $330,918.)
74-75	$ 99,266
	(Partial Year: to January 1, 1975--1/4 year.)

Table 29
State of Michigan Auto Insurance Premiums

Year	#Vehicles	Premium	%Cars	%Trucks	Prem/Car	Prem/Truck	Prem/Other
75-76	13,345	$540,272	65	23	$42.41	$42.41	$25.44
76-77	13,302	$943,382	64	23	$68.58	$68.58	$41.44
77-78	13,885	$818,627	64	23	$54.99	$54.99	$32.99
78-79	14,432	$973,412	65	23	$74.44	$70.24	$20.69
*79-80	14,852	$996,284	65	23	$85.73	$49.87	$13.84

*Estimated

The insurance is carried with Wolverine Insurance. In addition to the cost of the coverage, property damage is self-insured. Damaged cars may be fixed at the state garage if convenient, or, if damage occurs too far for this to be practical, at private garages. In the last year, 628 cars were repaired, 32 were totally demolished in a crash, and 153 were damaged and sold at a loss rather than repaired.

The motor pool division reported a loss of $144,028, of which $44,183 was paid by the division that owned or was using the car at the time of the crash and $99,845 was collected from other insurance carriers, leaving a net cost to the state of $44,183.

Thus, the cost to the state for automobile insurance is currently about $1,040,467, i.e., $996,284 + $44,183 for the 1979-1980 fiscal year. If we add in the cost of automobile insurance at state universities that were given above, the total cost of insurance and damage to state vehicles is $1,308,375. In round numbers, $1.3 million is considered the "best" estimate.

Since insurance costs are directly related to the accident experience of the fleet, a decrease in the number of accidents involving state vehicles will eventually lead to a decrease in both these auto insurance premiums and uninsured damage repair costs.

3.0 INDIVIDUAL CASE HISTORIES

In estimating the direct costs to the State which result from traffic accidents, this report has drawn mainly on aggregate data, and these result in statistics and charts illustrating breakdowns in costs, types of government agencies involved, and much other detailed non-personal data. The fact is that traffic injuries lead to substantial changes in personal life style as well as to public expenditures. In this section we will review some specific case histories of people involved in crippling automobile accidents, including statistics and costs as they relate specifically to those individuals.

The case histories included here involve individuals who received serious injuries as the result of a traffic accident and incurred enormous costs, a large portion of which has been and/or is still being borne by the state. It is difficult to assess the exact number of such individuals in the State but the cost for the care of just one such victim is prohibitive. These case histories are intended to put the statistical information collected in this report into perspective.

Case Number One

The first case history is that of a 18/19 year-old male who was injured in December 1965 in an automobile accident. Apparently, when he encountered car trouble, a friend of his "borrowed" a pickup truck without permission from his place of employment and used it to take him home. At 2:30 in the morning, their pickup truck hit a utility pole.

The male passenger was pinned in the vehicle for some time before he was extricated and removed to a local hospital where his injuries

were treated. Because of confusion over identification, he was presumed to be the other young man, and surgery was performed without parental permission.

Following surgery, he was removed to a local hospital where he remained for approximately ten months. He suffered from a severe head injury in addition to fractures of the lower extremities.

Because of his condition, he was taken to a Rehabilitation Center for roughly a four-month period and then returned to his home for a period of 11 months. While home he was given physical therapy. In January of 1968, he was taken to the a State Hospital where he remained until his death in July, 1980.

He not only had a personality behavioral problem because of the severe head injuries, but was unable to maintain his balance and so was confined to either bed or a wheelchair. His death in 1980 was caused by a fall from his wheelchair resulting in a subdural hematoma.

The substantive medical costs this one individual accrued are listed below:

Initial Rehabilitation	$11,564 (Major Medical)
Rehabilitation Center	$ 4,500 (Major Medical)
State Hospital	$183,212 (90% State money)
Pre-death Hospitalization	-- (amount unknown)
Social Security	$ 7,650 (paid while in (Traverse State Hospital)
Burial Costs	$ 2,000

Breakdown of Social Security Payments:

1968-1976 (9 years)	$600/year x 9 =	$5,400
1977	$ 56/mo. x 12 =	$ 672.
1978	$ 61/mo. x 12 =	$ 732.
1979	$ 43/mo. x 12 =	$ 516.
1980	$ 55/mo. x 12 =	$ 330.
		$7,650.

Case Number Two

The individual in this case history suffered permanent brain damage from a collision with a train.

In January 1972, this 55-year-old male was driving his automobile on a snow-covered road at night in the middle of a snowstorm. He proceeded through an unguarded railroad crossing and was struck in the right side by a train. The driver of the automobile sustained a severe closed head injury; his nine-year-old passenger was killed.

Because of the severity of his injuries, the driver remained in critical condition for several months, followed by a long period of institutionalization in several different hospitals and long-term care facilities. As of the present writing, it has been over nine years since the accident and he is still institutionalized. It is likely that this situation will not change. He cannot speak nor can he care for himself. He has some motor ability but is unable to dress himself. A civil suit was filed against the County Road Commission and resulted in a $687,000 settlement.

A breakdown of expenses follows:

Initial Hospitalization	$16,171.00	
Convalescent Center	$ 2,383.00	(Blue Cross)
V.A. Hospital	$ 3,083.00	
Convalescent Center (January 1973-January 1974)	$ 8,200.00	(Private Pay)
County General Hospital (January 1974-February 1974)	$ 2,218.00	(Blue Cross)
Convalescent Center	$15,988.11	
Convalescent Center (August 1976-Sept. 1980)	$63,239.00	(Private Pay)
	$112,237.11	

Case Number Three

This 24-year-old male, married father of one child, was driving on a roadway approaching a raised bridge area, on the other end of which

was a disabled truck. He proceeded over the rise in the road and was unable to avoid the collision.

His initial hospitalization was for three months; he was then moved to a convalescent center for more than one year. On multiple occasions, he was taken to a rehabilitation institute for a total period of approximately nine months for treatment. During this period, several surgical procedures were required to his lower extremity. Between stays at the rehabilitation institute, he remained in nursing homes and convalescent centers.

Initially he was unconscious for two months and had associated jaw and neck injuries. His current problems are short-term memory loss, inability to dress himself without help, hygiene, bladder and bowel incontinence, loss of significant balance, left-side motor loss, and seizure disorders. He is basically mentally impaired.

Now, four years post crash, he is still institutionalized in a convalescent center. The costs were:

Post-crash Hospitalization	Additional Hospitalization
$50,000 Medicaid	$3,117 Medicaid
$ 5,000 Family (unpaid)	$7,690 Medicare
$55,000	$1,638 Blue Cross
	$ 265 Family (unpaid)
	$12,710

Multiple Convalescent Centers	Rehabilitation Institute
$17,156 Medicaid	$17,858 Medicaid
$ 434 Medicare	$26,792 Medicare
$ 5,187 Social Security	$ 2,280 Social Sec.
$19,081 Family (unpaid)	$46,930
$41,858	

For a 42-month period, the total of the various pay sources provided:

Medicaid	$88,131
Medicare	$34,916
Social Security	$ 7,467
Blue Cross	$ 1,638

Family (unpaid)	$24,346
	$156,498

The total amount for this man's medical treatment and care, for 42 months, totals $156,498, or $3,176 per month.

4.0 INDIRECT COSTS

As mentioned in Section 2.0, there are indirect costs to the state resulting from traffic accidents. Components of indirect cost to the State of Michigan include the following:

(1) Traffic (civil and criminal) cases handled by State courts

(2) State income tax lost because of lost work time

(3) State police time in accident investigation and assistance

(4) Prisoner and probation costs resulting from criminal convictions

A decrease in the number of accidents should result in a proportional reduction in court cases, state police (accident investigation) hours, and prisoners in state-operated prisons. These reductions can be perceived as financial benefits to the State.

Increased highway safety should also decrease employee absenteeism. The result will be more hours worked and increased State revenue from income tax.

However, it is debatable whether the events described above would actually happen. If the number of accidents were reduced, the state police would likely elect to shift the work load of each policeman, or redefine their jobs to include other responsibilities. This would be a non-monetary benefit over a short period of time. If the accident rate decreased substantially (say 50%) over several years, this might be reflected in a smaller police department.

Since the State courts are presently overloaded, reducing the number of traffic accidents will not necessarily lower the number of court cases annually. The effect of a decreased number of accidents

will be reduced waiting time for litigation. The proportion of the total number of court cases saved by reduced traffic cases will determine whether the state courts can reduce their annual case load. If suits involving accident victims constitute a significant portion of the state court cases annually, then a reduction in the number of traffic accidents will result in a decrease in the number of cases handled by the state courts.

The large number of traffic accidents obviously results in a loss of State income tax paid annually by individuals. However, it is questionable whether this loss is substantial. If a person is injured in a traffic accident and cannot work for a short period of time (i.e., less than one month), the state could suffer a loss of income tax equal to 4.6% of the employee's wage adjusted for the number of exemptions claimed ($57.69 per exemption per month). In some cases, sick leave would be received and tax revenues might not decline, while in other cases the injured person would remain on salary. Furthermore, if an accident victim becomes disabled for a long period of time, it is likely that someone will be hired to take his place. Assuming this person was previously unemployed, the loss of tax revenue to the state would not be substantial. Therefore, it is necessary to examine occupations for which employed persons do not have sick leave benefits. Even in these cases, taxable income (for the state) is not always lost in these occupations when an employee is hurt and is absent less than one month. For example, if a person is employed by a fast food chain, the restaurant will likely increase the hours of other workers to offset the hours not worked by an employee absent from work as a result of a crash. Thus, it is difficult to identify occupations where a loss of wages will

occur when an employee is absent from work due to injury in a traffic accident. There seem to be very few occupations for which a loss of wages will always occur. In the absence of other data, a gross estimate of the loss of state income tax may be arrived at as follows.

From the Michigan Accident File, there were 976,753 occupants involved in crashes in Michigan in 1979. In the National Crash Severity Study (NCSS), 72% of all occupants involved in crashes were between the ages of 18 and 60. Therefore, (976,753) (.72) = 703,262 represents the total number of occupants involved in Michigan crashes who were between the ages of 18 and 60. From the Michigan Accident File we find that 66.1% or 464,856 occupants aged 18 through 60 were male, and 33.9% or 238,406 occupants were female. From the Michigan Statistical Abstract 1980[17] we find that the labor force participation rate was 80.7% for males and 48.4% for females. Therefore we obtain 375,139 = (464,856) (.807) as an estimate of the number of males in the labor force involved in crashes. Similarly we obtain 115,389 = (238,406) (.484) as an estimate of the number of female labor force members involved in crashes. Thus, 490,528 members of the labor force were involved in crashes in 1979. Assuming a 10% unemployment rate we obtain (490,528) (.90) = 441,475 as an estimate of the number of employed occupants. In the NCSS, 8.2% of all employed occupants involved in crashes lost between one day and one month of work. Assuming that this distribution of work days lost also applies to Michigan, we obtain (441,475) (.082) = 36,201 as an estimate of the number of persons who

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[17]Michigan Statistical Abstract 1980 (15th Edition). Michigan State University, Division of Research. September 1980.

will be absent from work between one day and one month due to injury in a traffic accident.

To estimate the amount of lost state income tax, we need to determine how many of these 36,201 workers are employed in occupations where a loss of wages will occur when an employee is hurt and is absent from work less than one month. We will assume that if an accident victim is severely injured, so that more than one month's work will be missed, another person will be temporarily hired to take his place, or another qualified individual will work extra hours and thereby earn higher wages. For example, if a dentist is injured in a crash and is not able to work for several months, we will assume that another dentist will take on extra patients and therefore nullify the loss of wages incurred by the dentist who was injured.

In the Statistical Abstract of the United States 1980, a comprehensive list of occupations is given. Three occupations for which total wages would decrease were identified. These were:

(1) Receptionist

(2) Hucksters and peddlers

(3) Self-employed agricultural workers

There are other occupations where wages would be lost in some but not most cases. For example, lost wages may occur when a secretary is absent from work as a result of a traffic accident. Since such cases are probably rare (many secretaries have benefits) they have been excluded from the calculation. Thus, our estimate of the indirect cost to the state due to loss of state income tax will be conservative.

Furthermore, it will be assumed that self-employed agricultural workers injured in a crash will lose wages 25% of the time. In most

cases, a self-employed farmer will harvest his crop despite being injured in a traffic accident. From the Statistical Abstract of the United States 1980, we find that 0.6% of all the workers in the U.S. are receptionists, and 0.2% are hucksters or peddlers. The Michigan Census Data for 1970 reveals that 1% of all employees are self-employed agricultural workers.

Assuming that the above percentages are true for employed persons in Michigan injured in a traffic accident and absent from work less than one month, and that 25% of the self-employed agricultural workers will suffer a loss of wages, we find that 1.05% = 0.6% + 0.2% + (.25)(1%) of all Michigan workers work in occupations where injury in a traffic accident would result in a reduction of wages. Since 36,201 employees lost between one day and one month as a result of a traffic accident, we find that 380 = (36,201)(.0105) employees work in occupations where wage losses would be incurred. The distribution of work days lost in the NCSS is shown in Figure 1 below. From the NCSS we find that 5.396 is the average number of work days lost by people absent from work between one day and one month as a result of a traffic accident. Assuming that this figure also pertains to Michigan accidents, we find that 2,050 = (380)(5.396) is the total number of work days lost per year by receptionists, hucksters and peddlers, and 25% of all self-employed agricultural workers, as a result of injuries in traffic accidents that disabled them for less than a month.

Receptionists, hucksters and peddlers, and self-employed agricultural workers are not paid particularly high wages. To keep our estimate conservative, we will assume that these people make the minimum wage of $3.35 per hour, or $26.80 per day. Since the average family

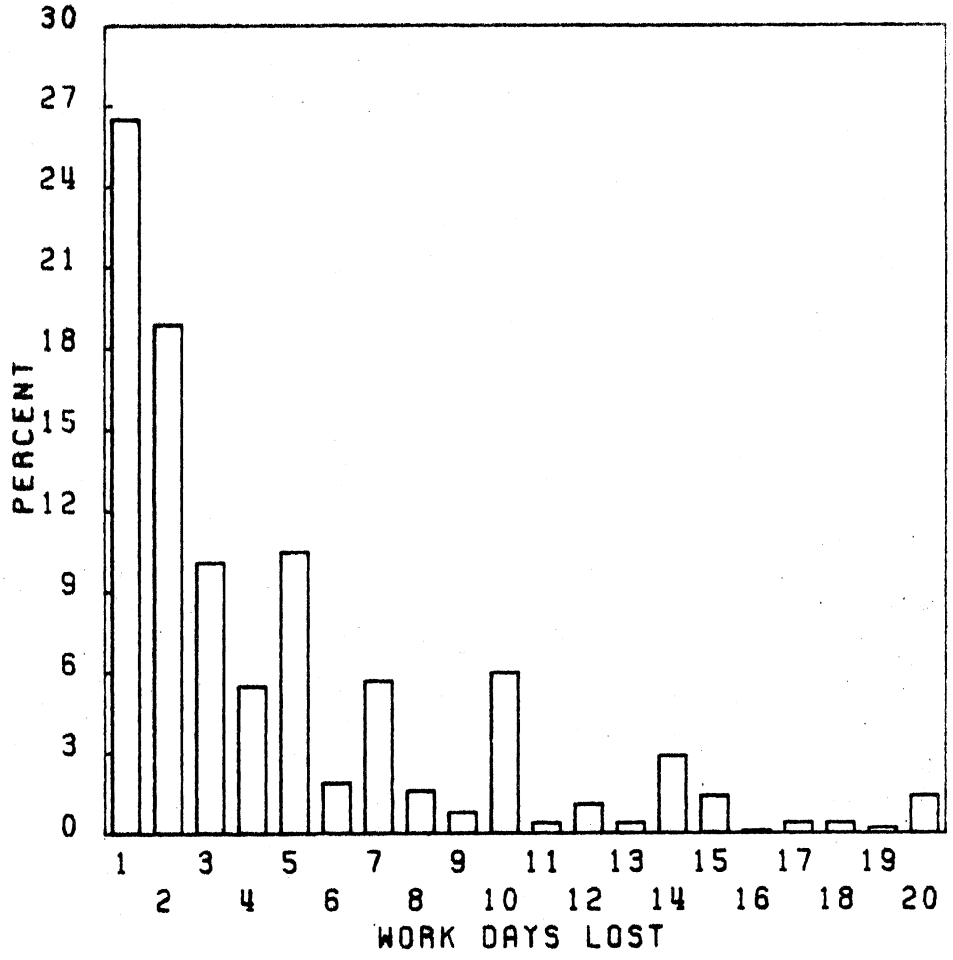

Figure 1

size is approximately four and unmarried people can claim only one exemption, we will assume that these employees have, on the average, two exemptions. A person receives $57.69 per exemption per month. Therefore, a person claiming two exemptions receives a tax break of $3.79 per day. Thus, a person making the minimum wage will have $23.01 equal $26.80 minus $3.79 in taxable income per day. The state receives 4.6% of an employee's taxable income. Therefore a person making the minimum wage will pay $1.06=($23.01)(.046) in state income tax per day.

The information above leads to an estimate of the indirect cost to the state due to loss of state income tax. The state will lose $1.06 in taxes for 2,050 lost work days. The indirect cost to the state is thus $2,173.

In summary, the effect of work days lost on the gross state product is almost negligible. This is because in most cases either sick leave is available or substitute employees replace the loss. Specific legislative measures aimed at reducing traffic accidents will likely have little effect on this component of indirect cost, because there are very few occupations where wage losses occur when people are absent from work.

The most undesirable characteristic of indirect costs is that they are extremely difficult and at times impossible to measure. Further, whether they are a cost is debatable. Perhaps the best that could be done is a ballpark estimate of the number of court cases, prisoners, and state policemen hours saved by reducing the number of traffic accidents. The determination of the amount of state income tax lost and whether an injured worker will be subsequently replaced involved some extrapolation. With this in mind, little attention was given in this project to further measurement of indirect costs. Such costs will not be considered in the summary.

5.0 SUMMARY OF TOTAL DIRECT COSTS TO THE STATE

The best estimates of each component of direct cost to the State developed in the previous sections are summarized in Table 30. It should be emphasized that these costs are costs to state tax funds and not the total cost of traffic accidents. Previous research[18] has estimated the total cost to society of traffic accidents. This cost includes many factors not considered here, such as costs to other levels of government, hospital/medical insurance, automobile insurance, and intangible costs resulting from pain and suffering. The costs estimated in Table 29 represent only those direct dollar costs requiring the expenditure of state tax revenues. This is not to diminish the importance of the other costs, but merely to highlight the burden on state taxes imposed by traffic accidents.

As discussed in the individual subsections of Section 2, some of these estimates are more precise than others. The estimate of litigation and judgment costs, unreimbursed road repair costs, and auto insurance costs are based on primary data sources. A primary data source exists for the costs from Medicaid in the Medicaid records, but this has been inaccessible to date. As a consequence, the Medicaid estimate is a projection based on other data. The costs for special education and for the Crippled Children's Fund are based on estimates of the number of individuals involved, combined with a known cost per individual. Thus, if better estimates of the numbers involved can be found, these estimates can be made quite solid. State employees' sick

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[18] "Societal Costs of Motor Vehicle Accidents for Benefit-Cost Analysis" Faigin, July 1975.

Table 30

Cost Component Estimates

Source	Estimated Annual Cost in Millions	Type of Cost*
Care in State Institutions	0.1	I
Medicaid	8.9	I
ADC	3.1	I
State Employees Sick Leave	0.7	I
Litigation and Judgement	3.6	P,I
Special Education	0.5	I
Crippled Children's Fund	0.1	I
Unreimbursed Road Repairs	2.7	P
Auto Insurance for State-owned Vehicles	1.3	P,I
Workers' Compensation	0.2	I
Total	21.5	

*I denotes costs resulting directly from injuries; P denotes costs resulting from property damage.

leave, Workers' Compensation, and ADC costs are estimated by an extrapolation method, since again the cases resulting from traffic accidents cannot be directly determined.

The cost components in Table 30 may be classified into three types. Some costs result directly from injuries and would be reduced if either the number and/or the severity of traffic accident injuries were reduced; other costs result entirely from property damage. These are coded "I" or "P," respectively, in the last column of Table 30. Presumably they would be reduced if the number of accidents were reduced. A third group of costs has components resulting both from personal injuries and from property damage. Unreimbursed road repair is a cost that results only from property damage to roads and roadway

furniture. Litigation and judgment costs and Auto Insurance Costs for State-owned vehicles may contain both property damage and injury components. The other cost components result primarily from injuries.

Proposed interventions could affect these costs differentially, depending on the primary effect of the intervention. For example, the child restraint law would affect those cost components that result from injuries to children. These would primarily be Special Education and Crippled Children's Funds, but might include litigation and judgment costs. An intervention such as requiring restraint usage that would result in reduction in injury severity would presumably affect those components that result from injury. Finally, an intervention such as the reduction of the speed limit might result both in reduction in the number of accidents and in the severity of injuries. Reduction in the number of accidents should also reduce the number of injuries. Section 6 presents some examples illustrating how the numbers in Table 30 might be considered with respect to proposed interventions, estimating the reduction in the direct cost to the State from that intervention.

6.0 APPLICATIONS

It should be clear that state government incurs many direct expenses as a result of highway accidents occurring in the state. As noted in earlier sections, these include state support of hospitals where treatment of injury has not been otherwise paid for, sick leave for state employees unable to work because of accidents, insurance premiums for state agencies and educational institutions, uncompensated damage to highways and highway furniture, aid to dependent children whose dependence resulted from automobile accidents, etc.

Legislation related to highway safety is frequent and is generally enacted with the ultimate purpose of reducing the number of accidents and/or injuries within the jurisdiction. Examples of such countermeasures are changes in driver licensing policies, vehicle inspection procedures, requirements for using protective equipment. With the emphasis on cost/benefit justification, a variety of studies have been prepared to show the net benefit to society of the enactment of such legislation.[19]

Such benefits may accrue to many individuals and organizations. A reduction in total accidents will surely benefit insurers, reduce the pain and suffering for persons who remain uninjured, and save the expenses to the individual vehicle owner for damage repair. While legislators may properly take into account these reduced expenses to individuals or corporations, they may also consider cost reductions directly in the state budget. The purpose of this study has been to acquire and analyze existing data with regard to such costs and

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[19]"Societal Costs of Motor Vehicle Accidents for Benefit-Cost Analysis" Faigin, July 1975.

benefits, to identify that portion of the costs paid by the state, and to provide a means of estimating likely benefits from particular legislation.

6.1 Potential Cost Savings

Two particular populations will be considered here in exemplifying the methods of estimating cost savings. The first of these is the group of children less then five years of age injured as occupants of passenger cars, and the second is all of the occupants of the same passenger cars. The NCSS data permit (with some assumptions) an estimate of the numbers of injured persons by what is called "NCSS Class"--an identifier assigned to each reported occupant. The levels of this categorical variable are shown as the left column in Tables 31 and 32. Table 31 presents an estimate of the number of 0- to 4-year-olds who were occupants of crashed/towed passenger cars in Michigan in one year. The extrapolation from the NCSS data was made by considering NCSS to represent about 1/50 of the accident population of the country for 27 months, and then computing an estimate for Michigan for one year by a simple population proportion adjustment. The number of 0- to 4-year old passenger car fatalities projected by this method is 21; the actual number reported in the Michigan police files is 19 for 1978. Less than 7% of the occupants reported in the NCSS data were identified as using restraints at the time of the crash. In the following analyses it will be assumed that these data represent an unbelted population.

Children aged 0 to 4 account for only 3% of the passenger car occupants in crashes reported in the National Crash Severity Study, and account for slightly less than 2% of the fatalities in NCSS (actually they are 2.5% as measured by the National Fatal Accident Reporting

Table 31

Injury Distribution for 0-4 Year-old Towaway Passenger Car Occupants
NCSS and Michigan Estimated Populations

Injury Class	NCSS 27 months	Michigan 1 year
Killed	19	21
Hospitalized . .	102	113
Treated/Released	805	894
Other Treatment	273	303
Not Transported	145	161
No Injury . . .	1980	2200
Unknown	6	7
Total	3330	3699

Table 32

Injury Distribution for All Towaway Passenger Car Occupants
NCSS and Michigan Estimated Populations

Injury Class	NCSS 27 months	Michigan 1 year
Killed	1032	1147
Hospitalized . .	6383	7092
Treated/Released	23315	25906
Other Treatment	11072	12302
Not Transported	6267	6963
No Injury . . .	64039	71154
Unknown	537	597
Total	112,645	125,161

System). From the Michigan Statistical Abstract 1980, 0- to 4-year-olds represent about 7.6% of the Michigan population. Furthermore, from the NCSS, only 3.1% of the 0- to 4-year-olds are injured are injured so as to require hospitalization (as compared with the average 5.7% for all

ages). Nevertheless, injuries to children are of special concern, and many parallel efforts have attempted to educate parents to the value of special child seats in reducing the probability of injury.

Table 32 presents similar data for the entire passenger car occupant population. As discussed above, there are additional injured persons who were cyclists, pedestrians, occupants of trucks, and other non-towed-away cars. These two tables, however, represent the majority of passenger car injuries and serve as the basis for considering methods for protecting car occupants.

6.2 Child Seat Legislation

Two hypothetical proposals for legislation will be considered. The first would provide state funds to subsidize a part of the purchase price of an approved child seat--appropriate for the age group 0-4 discussed here. Michigan has in recent years averaged about 140,000 births per year.[20] Assuming that a child seat is purchased for each infant, and that it lasts and is used (through trading or otherwise) for the full five-year period, the subsidy would assist in the purchase of 140,000 seats per year. If the new seats were completely effective in eliminating injury and fatality to this passenger car population, the savings to the state may be estimated as 3.1% of the total cost to the the state shown in Table 30, or about $666,500. Dividing this by 140,000 child seats results in a predicted savings of about $4.75 per seat. Thus the value to the state of universal child-seat usage would be about $4.75 times the "effectiveness" of those restraints in eliminating injury.

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[20] Michigan Statistical Abstract 1980.

That child seats can be effective in reducing injury is clear from laboratory tests. A field measurement of their effectiveness may be derived from the NCSS data. Table 33 shows the weighted 27-month NCSS estimates for injury categories of children aged 0-4 by three restraint classifications. The category "none" was used for "not used," "not available," and for missing data. The category "Adult" includes 9 children wearing a lap and upper torso restraint, and 54 using a lap belt alone. The category "Child Seat" includes all reported child seat use without consideration of the degree of approval of the seat. While there were no fatalities among the restrained group, the difference is not statistically significant, even with the weighted frequencies. A best estimate, however, is a reduction of 36% in the probability of injury for the two restrained groups compared with those unrestrained. Applying this factor to the estimated reduction in state costs results in an estimated savings to the state of about $1.70 per child seat.

A more precise estimate of the cost to the state of such child injuries might be made by summing the appropriate proportions of special education and crippled children's fund expenditures--both clearly higher than the 3.1% used above. However several other categories do not apply to children at all (e.g., damage to state-owned vehicles, ADC state employees sick leave). The result of this alternative computation is slightly lower than the amounts listed above ($573,000).

A legislator who was thinking only of the direct value of a subsidy to the state might propose to place child seats in a category requiring no sales tax (like prescription medicine), balancing the loss in sales tax revenues from child seat purchases against the expected savings of $1.70 per child seat purchased and used. A legislator considering

Table 33

Fatalities and Injuries among 0-4-Year-olds
by Restraint Use (NCSS 27-month Data)

Restraint Type	Fatal Injury	Hospital-ized	Treated and Released	Other Injury	Not Injured	Total
None . . .	19	96	753	408	1830	3106
Adult . .	0	0	6	19	38	63
Child Seat	0	5	28	10	112	155
Total . .	19	101	787	437	1980	3324

societal loss as a whole might propose a tax credit of $20 or more to those purchasing such seats, balancing this tax credit cost against the expected societal savings, as might be computed from the methods of Faigin.[21]

6.3 Mandatory Restraint Usage for All Occupants

The second possible action to be considered is legislation to encourage the use of available restraints in the whole traveling population. With rare exception, the passenger cars on the road today in Michigan are equipped with both lap and upper torso restraints, so that the vast majority of car occupants have this protection available. The second column in Table 32 represents the estimate of the number of persons in each injury category in a one-year period for the State of Michigan. The total population of Michigan in 1980 was approximately 8.9 million.

[21] "Societal Costs of Motor Vehicle Accidents for Benefit-Cost Analysis," Faigin, July 1975.

Numerous estimates have been made of the effectiveness of restraint use in reducing the probability of injury or death for car occupants. A NHTSA review in 1979 estimated on the basis of many studies that the number of front seat occupant fatalities that might be eliminated annually in the U.S. by airbags was between 6300 and 9200.[22] A General Motors review of 706 fatal accidents concluded that full use of lap and upper torso restraints would achieve about the same result.[23] Australian experience from "mandatory" restraint usage has been reported to achieve about an 18.2% reduction.[24] Without arguing for acceptance of either end of this spectrum, there seems to be a potential for saving the state a substantial fraction of the direct costs shown in Table 29.

In countries which have enacted seat-belt laws, compliance has varied from about 50% upwards. Actual rates must depend on a combination of enforcement, education, convenience of the belts, and the public attitude. A first estimate of effectiveness for car occupants might be computed by multiplying the wear rate by the expected injury-reduction rate. Assuming that seat belts when worn are 30% effective in reducing injuries, and that the level of use resulting from a seat belt law would be 80%, this would result in a 24% reduction in injuries. Applying this to the state costs associated with injury in Table 39

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[22] Passive Restraints for Automobile Occupants--A Closer Look. U.S. General Accounting Office, Report CED-7993, Washington, D.C., July 27, 1979.

[23] "Restraint System Effectiveness--A Study of Fatal Accidents," R. A. Wilson and C. M. Savage. In Proceedings, Automotive Safety Engineering Seminar, June 20-21, 1973.

[24] "Victoria and the Seat Belt Law, 1971 On," D. C. Andreassand. Human Factors, Volume 18, Number 6, pp. 593-600, 1976.

(approximately 18.3 million dollars) results in an estimated annual savings of about 4.4 million dollars.

Thirty-six of the United States have (by 1981) enacted or considered legislation requiring some form of occupant protection for young children traveling in motor vehicles.[25] Although the direct benefits in reduced state expenditures are minimal, the total benefits are certainly in line with the cost of additional protective equipment needed. Further, there is the long-term possibility that children who are properly restrained from age 0 to 4 will grow into adults routinely donning the restraints which were available but unused by their parents. In terms of more immediate payoff to the state budget, legislation which would induce the entire traveling public to use their restraints would be even more appropriate. From the point of view of costs to the state, the expenditures necessitated by mandatory restraints for all occupants would likely be more than balanced by potential income from fines. Victoria (Australia), with a population less than half that of Michigan, reported about 20,000 citations per year for failure to comply with the restraint law in the early years, a small rate compared with the U. S. estimate of 20,000,000 speeding violations each year. Direct costs to the state might include installation of signs at the borders or on principal roads, education of the public through the media, rewriting of state driver manuals, etc. Ontario law provides for a fine of $20 to $100 for failure to comply with the belt-wearing law. The minimum value of that, coupled with the citation rate of Victoria, would produce more than $1,000,000 per year in Michigan.

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[25] Highway and Vehicle Safety Report, Volume 7, Number 10, Stamler Publishing Company, February 9, 1981.

6.4 Comparing Mandatory Restraint and Child Seat Legislation

Benefits to the state budget resulting from universal use of approved child restraints are not large. This results not from the lack of effectiveness of the restraints, but from the fact that young children are underrepresented in the accident population. Children aged 0 to 4 represent about 7.5% of the total population, but account for only 3.1% of the occupants of crashed vehicles, and only 2.5% of the fatalities. It can be argued that children should be afforded proper restraints when traveling in cars, but it is difficult to support total subsidization of the child seats on the basis of savings to the state alone.

Mandatory restraint usage by the general population, on the other hand, is likely to have its direct costs reimbursed by a modest enforcement and penalty procedure. Direct benefits to the state, using 15% and 30% injury reduction factors, would be on the order of $2,750,000 to $5,490,000. Benefits to the general public would be substantially larger.

6.5 Countermeasures Aimed at Accident Reduction

The restraint systems countermeasures would be intended to reduce accident severity rather than number. Thus their value (in reducing costs to the state) would be primarily associated with lower hospital and nursing home expense, although some reduction in liability suits for injury "caused by" road deficiencies might be expected.

Countermeasures intended to reduce the number of accidents (as opposed to their severity) may also be considered. While laboratory and some field data are available to estimate the effect of, say, a 50% increase in restraint system wearing, there are few accident-reduction

programs which can be so easily quantified. Nevertheless, decisions must often be made to adopt or deny such proposals as improvements in the driver education system, increases in law enforcement capability, or physical changes in the highway system. Of these, the latter is no doubt the most quantifiable because such changes (e.g., the installation of the left turn lanes) are rather directly related to the accident process. Changes such as the introduction of simulators into the driver education program, a marginal increase in the police patrol hours devoted to traffic patrols, or changes in the number of warning letters sent by the driver licensing authority are much more difficult to evaluate, although they may indeed have strong effects.

The costs to the state for implementation of countermeasures will vary widely. Patricia Waller, of the University of North Carolina's Highway Safety Research Center, reported that a North Carolina law requiring motorcycle headlights to be on in the daytime was credited with saving 40 fatalities and 1,470 injuries over a five-year period.[26] The total societal costs saved, using the methods of Faigin, were estimated at 14.5 million dollars. Actual savings to the state (on an annual basis) would, of course, be considerably less than this, but the cost of implementing such legislation would be quite small.

A change with higher direct cost to the state might involve mailing a warning notice to drivers who have accumulated a lesser number of points than the present practice calls for. If the increase in the number of drivers so treated were, say, 50,000 per year with a cost (for printing, mailing, etc.) of $2.00 each, one might reasonably consider

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[26] The Impact of Motorcycle Lights-on Law: an Update, Patricia Waller and Lindsay Griffin. Highway Traffic Safety Center, University of North Carolina, 1981.

what reduction in accident rate might be necessary for the state to break even. These 50,000 drivers might initially have a higher than average accident rate, and one could compute the likely savings to the state if they exhibited a 10% or 20% reduction as a result of the warning. A sample computation follows:

There are approximately 6,250,000 licensed drivers in Michigan. In 1979 there were 366,701 accidents reported in the Michigan Accident Data. Thus the 50,000 drivers to receive letters would probably be involved in about 3000 accidents--higher than average. If these drivers showed a 10% to 70% reduction in accidents as a result of this warning letter, this would be 300 to 600 accidents per year. The reduction in state costs would be proportional, that is, from $17,500 to $34,700 per year, less than the assumed cost of $100,000. To break even, this program would need to prevent about 1730 accidents per year, which could occur if the letters were about 60% effective or if these drivers had twice the normal accident rate and the letters were 30% effective.

6.6 Other Factors

There are, of course, many "costs" associated with highway safety countermeasure programs are not easily expressed in dollar terms. These include the imposition of regulations that restrict one's freedom to travel in some way; the increased travel time associated with the 55 mph speed limit is an example. Decision makers must, of course, weigh such factors against expected cost and injury savings. Nevertheless, the direct saving of public money by the enactment of highway safety legislation is worth considering, and it is hoped that this report will provide information that permits such computations.

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