Costs of Motor Vehicle Accidents and Injuries

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ABSTRACT

Motor vehicle accident costs are an important component in benefit-cost evaluations of highway safety improvements. A recent study by Miller et al. for the Federal Highway Administration evaluated various approaches to accident cost estimation and presented state-of-the-art societal costs of motor vehicle accidents, based largely on a 1983 accident cost study by the National Highway Traffic Safety Administration. The principal shortcoming of the Miller et al. study is its failure to express accident costs in a form that can be directly used with state accident data in benefit-cost calculations. The objective of this paper is to develop accident costs that can be used directly with state accident data in benefit-cost evaluations of highway improvements. The costs in Miller et al., which were expressed in per-victim and per-vehicle terms, provide the basis for the per-accident costs developed in this paper. These accident costs are based on accident severities and on the A-B-C injury severity scale commonly used in state accident records, rather than on the Maximum Abbreviated Injury Scale (MAIS) used by NHTSA and Miller et al. Accident data from five states are used in deriving the accident costs. Data from the National Crash Severity Study (NCSS) and the National Accident Sampling System (NASS) are used to relate percentage distributions of injury severities by the MAIS and A-B-C scales. The accident costs presented in this paper can be used directly with state accident data, thereby facilitating the use of state-of-the-art accident cost estimates in benefit-cost analyses of highway improvements.

A major problem faced by administrators is how to allocate limited highway safety funds to achieve the maximum reduction in fatalities, injuries, and property damage resulting from motor vehicle accidents. Recognition of this problem has led to the development of advanced benefit-cost techniques for comparing the expected benefits and costs of various funding alternatives. Of central importance in benefit-cost evaluations of alternatives is the accurate estimation of motor vehicle accident costs.

Considerable effort has been devoted to developing accident costs. One of the most recent such studies by Miller et al. for the Federal Highway Administration (1) evaluated various approaches to accident cost estimation and presented what appear to be the best available societal costs of motor vehicle accidents.

The principal shortcoming of this study is its failure to express accident costs in a form that can be directly used with state accident data in benefit-cost calculations. Costs are expressed on a per-victim and per-vehicle basis, rather than on a per-accident basis, and are presented in terms of the Maximum Abbreviated Injury Scale (MAIS). However, benefit-cost analyses often are based on a state's accident data, which typically consist of numbers of accidents per year at various accident locations, with injury severities coded by the A-B-C scale (incapacitating, nonincapacitating, and possible injury, respectively) rather than by the MAIS (0, no injury; 1 to 5, least to most severe nonfatal injury; 6, fatality). Hence, costs such as those presented by Miller et al. (1) cannot be directly applied to state accident data and, therefore, may well be largely ignored in state traffic safety programs.

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The objective of this paper is to develop accident costs that can be directly used in benefit-cost studies with state accident data. Based on the values presented by Miller (1), the accident costs presented here were calculated by using methods previously developed in a study for FHWA (2). During the course of deriving these accident costs, a method for relating MAIS injury severities to the A-B-C scale is presented.

DATA SOURCES

The costs used to develop accident costs in this paper were taken from Miller et al. (1). The costs presented in that report were based largely on societal costs of accidents in an updated report by the National Highway Traffic Safety Administration (NHTSA) (3) and on a study by Hartunian et al. (4). Direct, indirect, and total costs from the study by Miller et al. (1) are summarized in Table 1. Specific components of direct and indirect costs are detailed in the study by Miller et al. (1) and in the NHTSA report (3).

The accident data used in estimating accident costs were compiled from accident records from five states (2): Alabama (90,163 accidents in 1980), Montana (18,185 accidents in 1979), North Carolina (94,366 accidents in 1979-1980), North Dakota (9,340 accidents in 1979), and Texas (627,166 accidents in 1978-1979). These particular states were selected because they responded to a request from FHWA to all states to provide data for a study (2). The data were combined into a single data set on the basis of the annual number of accidents in each state. The data base included such information as the numbers of vehicles per accident (passenger cars and trucks) in Table 2, accident proportions by severity for accidents in rural and urban areas in Table 3, and

TABLE 1 Costs by MAIS Categories (1980 dollars) (*1*, Tables 36-38)

Type of Cost	Cost per Victim (MAIS Categories)						
	0 (PDO)[a] ($)	1 ($)	2 ($)	3 ($)	4 ($)	5 ($)	6 (Fatality) ($)
Direct[b]	716	1,601	3,442	8,089	18,467	138,684	18,294
Indirect[c]	132	690	1,165	2,217	32,564	122,897	724,227
Total	848	2,291	4,607	10,306	51,031	261,581	742,521

[a] Costs per vehicle in reported property-damage-only (PDO) accidents.
[b] Direct costs include property damage, medical, legal, and funeral costs.
[c] Indirect costs include administrative costs, human capital costs (lost productivity) for injuries, and for a fatality, human capital costs adjusted for individuals' willingness-to-pay to reduce their risk of death or injury.

TABLE 2 Vehicle Involvements per Accident, Five States Combined (*2*)

Area	Accident Severity			
	Fatal	Injury	PDO	Average
Rural	1.3930	1.4264	1.5307	1.4901
Urban	1.4316	1.5399	1.7918	1.7392

Note: Alabama, Montana, North Carolina, North Dakota, and Texas are combined.

TABLE 3 Accident Proportions by Severity, Five States Combined (*2*)

Area	Accident Severity		
	Fatal	Injury	PDO
Rural	0.0160	0.3497	0.6343
Urban	0.0045	0.2458	0.7497

Note: Alabama, Montana, North Carolina, North Dakota, and Texas are combined.

numbers of fatalities and A-B-C injuries per accident in Table 4. Of course, to the extent that states differ in how data such as injury severities and rural-urban areas are coded in their accident records, the accuracy of the accident costs developed in this paper may be affected.

TABLE 4 Fatalities and Injuries per Accident, Five States Combined (*2*)

Accident Severity and Area	Number per Accident			
	Fatalities	A Injuries	B Injuries	C Injuries
Fatal				
Rural	1.1516	0.5315	0.3173	0.1396
Urban	1.0862	0.3528	0.3015	0.1298
All	1.1272	0.4648	0.3114	0.1359
Injury				
Rural	–	0.3457	0.5770	0.6027
Urban	–	0.1883	0.5990	0.6575
All	–	0.2516	0.5902	0.6355

Note: Alabama, Montana, North Carolina, North Dakota, and Texas are combined.

For relating MAIS injuries to the A-B-C scale, data were obtained from the National Crash Severity Study (NCSS) for 1977-1978 and the National Accident Sampling System (NASS) for 1979-1980. These two data sets included injuries cross-classified by the MAIS and A-B-C scales. The NCSS data set was used for injuries in fatal accidents because it had a larger sample of injuries in fatal accidents than did the NASS data. The NASS data set, with a larger sample of injuries in nonfatal injury accidents, was used for injuries in nonfatal injury accidents (2).

COST PER PROPERTY-DAMAGE-ONLY ACCIDENT

The cost per property-damage-only (PDO) accident can be readily calculated from the costs per vehicle involvement in Table 1 and the average number of involvements per PDO accident in Table 2. Direct, indirect, and total costs per PDO accident in rural and urban areas are as follows:

Direct cost = Direct cost per involvement x Involvements per accident = $716 x 1.5307 = $1,096 per rural PDO accident.

Direct cost = $716 x 1.7918 = $1,283 per urban PDO accident.

Indirect cost = Indirect cost per involvement x Involvements per accident = $132 x 1.5307 = $202 per rural PDO accident.

Indirect cost = $132 x 1.7918 = $236 per urban PDO accident.

Total cost = Total cost per involvement x Involvements per accident = $848 x 1.5307 = $1,298 per rural PDO accident.

Total cost = $848 x 1.7918 = $1,519 per urban PDO accident,

or, alternatively, total costs can be estimated as

Total cost = Direct cost + Indirect cost = $1,096 + $202 = $1,298 per rural PDO accident.

Total cost = $1,283 + $236 = $1,519 per urban PDO accident.

The difference in the costs per PDO accident is due to the greater number of involvements per PDO accident in urban areas than in rural areas. To the extent that the costs per involvement in rural and urban areas differ from the average involvement cost of $848 reported by Miller et al. (1), the estimated costs per PDO accident shown here over- or understate the actual cost per involvement by population area. Similarly, all of the accident costs developed here contain some inaccuracy arising from the fact that the source costs reported by Miller et al. (1) are not differentiated by rural and urban areas.

COST PER A-B-C INJURY

Because state accident records typically use the A-B-C scale for coding the severities of nonfatal

injuries, the MAIS scale cannot be used directly with state accident data in benefit-cost analyses. Therefore, a method was devised for relating the percentage distribution of MAIS severities to that of A-B-C severities (2).

This was done by using NCSS and NASS data on injury severities cross-classified by the MAIS and A-B-C scales. Tables 5 and 6 give the percentage distributions of injury severities by the two scales for injuries in fatal accidents and injuries in nonfatal injury accidents, respectively. It can be observed from these two tables that, in the NCSS and NASS sample data, some fraction of injuries coded as A, B, or C by investigating officers turned out to be no injury (MAIS-0) or, in other cases, fatalities (MAIS-6).

TABLE 5 Injuries in Fatal Accidents, Percentages Cross-Classified by A-B-C and MAIS Severities, Based on NCSS Sample

	A-B-C Scale			
MAIS	C (%)	B (%)	A (%)	Total (%)
0	0.30	0.30	0.00	0.60
1	5.86	17.90	14.99	38.75
2	0.75	5.86	13.51	20.12
3	0.60	3.90	19.21	23.71
4	0.30	1.05	9.16	10.51
5	0.00	0.15	5.86	6.01
6	0.00	0.00	0.30	0.30
Total	7.81	29.16	63.03	100.00

TABLE 6 Injuries in Injury Accidents, Percentages Cross-Classified by A-B-C and MAIS Severities, Based on NASS Sample

	A-B-C Scale			
MAIS	C (%)	B (%)	A (%)	Total (%)
0	2.84	0.46	0.07	3.37
1	32.45	30.38	6.08	68.91
2	2.97	7.36	6.67	17.00
3	0.82	2.94	4.70	8.46
4	0.04	0.36	1.25	1.65
5	0.00	0.16	0.42	0.58
6	0.00	0.00	0.03	0.03
Total	39.12	41.66	19.22	100.00

The data in Tables 5 and 6 were used in developing Figures 1 and 2, which can be used for relating MAIS severites to A-B-C severities for any state's percentage distribution of A-B-C injuries. In each figure, the cumulative percent of MAIS injury severities is plotted against the cumulative percent of A-B-C severities. For example, in Table 5, it is observed that C injuries accounted for 7.81 percent of all injuries in fatal accidents in the NCSS sample, with 0.30 percent of all injuries that were coded as C severity turning out to be MAIS-0 severity, 5.86 percent coded as C turning out to be MAIS-1, 0.75 percent coded as C turning out to be MAIS-2, and so forth. In Figure 1, the curves pass through points corresponding to these MAIS values on the ordinate for 7.81 percent C injuries on the abscissa.

Similarly, MAIS cumulative percentages from Table 5 (e.g., for MAIS-1, 17.90 percent + 5.86 percent = 23.76 percent) corresponding to B plus C injuries are plotted on the ordinate in Figure 1 for cumulative B plus C injuries on the abscissa (29.16 percent + 7.81 percent = 36.97 percent of all injuries in fatal accidents). The MAIS cumulative percentages

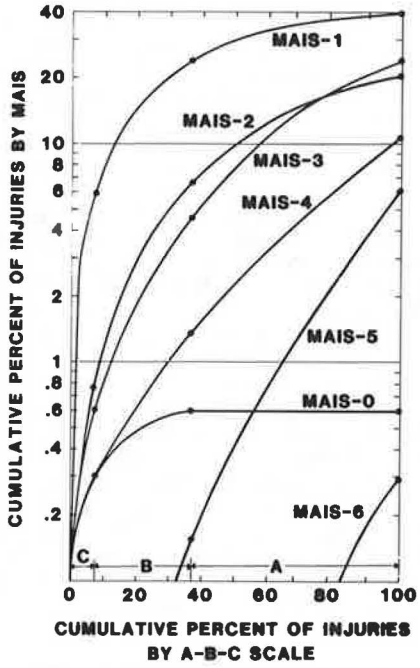

FIGURE 1 Cumulative percent of injuries by MAIS versus cumulative percent by A-B-C scale, injuries in fatal accidents, NCSS sample.

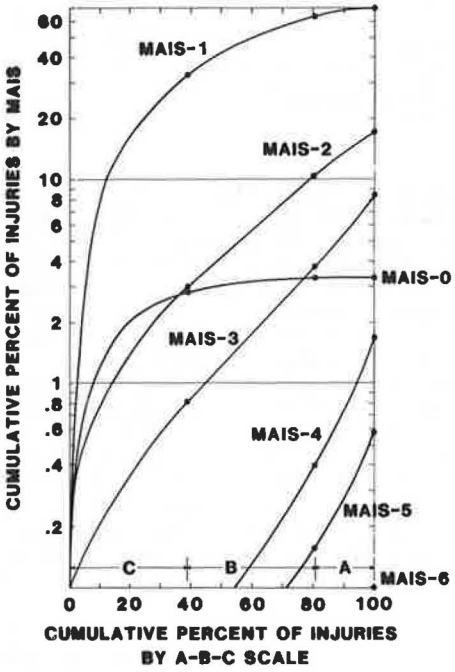

FIGURE 2 Cumulative percent of injuries by MAIS versus cumulative percent by A-B-C scale, injuries in injury accidents, NAS sample.

for all injuries (e.g., for MAIS-1, 14.99 percent + 17.90 percent + 5.86 percent = 38.75 percent) corresponding to A plus B plus C injuries are plotted for cumulative A plus B plus C injuries (63.03 percent + 29.16 percent + 7.81 percent = 100 percent of all injuries in fatal accidents in the NCSS sample).

Figure 2 was developed in a similar fashion for injuries in nonfatal injury accidents, using the NASS data in Table 6. The curves in Figures 1 and 2

were fitted through the four sets of points (origin, percent C, percent B+C, and percent A+B+C) in such a way that the vertical sum of the curves at any point of cumulative A-B-C injuries on the abscissa equals the corresponding cumulative percentage of MAIS severities.

Percentages by MAIS severities can be read from Figures 1 and 2 for any cumulative percentages by A-B-C severities from state accident data, establishing weights to apply to the costs of MAIS injuries and thereby producing the costs of A, B, and C injuries. From data for the five states combined, the percentage distributions of A, B, and C injuries in fatal accidents and in nonfatal injury accidents are given in Table 7. Costs per A, B, and C injury are estimated by obtaining percentages by MAIS severities corresponding to the A, B, and C percentages in Table 7 and then applying these weights to the direct and indirect costs by MAIS category in Table 1 (with adjustments for property damage per accident, as explained in the following paragraph). The costs per injury cannot be calculated separately for rural and urban accidents because this distinction was not available in the NCSS and NASS data used in developing Figures 1 and 2.

TABLE 7 Percentage Distribution of A-B-C Severities, Five States Combined

	Percentage Distribution of Injury Severities		
Accident Severity	A (%)	B (%)	C (%)
Fatal	50.96	34.14	14.90
Injury	17.03	39.95	43.02

Note: Alabama, Montana, North Carolina, North Dakota, and Texas are combined.
Source: Derived from Table 4.

The procedure for estimating the costs of A, B, and C injuries for injuries in fatal accidents and in injury accidents is as follows. From Table 7, the percentage distribution of A, B, and C injuries in fatal accidents is 50.96 percent, 34.14 percent, and 14.90 percent, respectively, whereas that of injuries in injury accidents is 17.03 percent, 39.95 percent, and 43.02 percent. From Figure 1, the MAIS percentages corresponding to 14.12 percent C, 46.22 percent B+C (equal to 32.10 percent + 14.12 percent), and 100 percent A+B+C (equal to 53.78 percent + 32.10 percent + 14.12 percent) for fatal accidents are given in Table 8, with a similar distribution for injuries in injury accidents derived by using Figure 2. For each MAIS category, the percentages of A and B severities are obtained by subtraction (B+C percentage - C percentage = B percentage, and A+B+C percentage - B+C percentage = A percentage). These percentages for A, B, and C severities given in Table 9 constitute weights for the MAIS costs in Table 1 (with adjustments for property damage, as explained in the following paragraphs) to generate costs per A, B, and C injury in fatal accidents and in injury accidents.

The MAIS direct costs per victim in Table 1 include a property damage component expressed as the average amount of property damage per victim (3). However, estimating the amount of property damage per accident necessitates the calculation of property damage on a per-accident basis rather than on a per-victim basis because the average accident includes more than one injury per accident and, in the case of fatal accidents, some injuries as well as fatalities (see Table 4).

Thus, to avoid double-counting of property damage, the direct cost of each nonfatal injury (MAIS-1 to MAIS-5) and fatality (MAIS-6) in Table 1 is adjusted as follows. The average amount of property damage per victim (1) is deleted from each direct cost total to give a net direct cost per MAIS injury as follows:

MAIS Injury	Direct Cost in Table 1 ($)	Property Damage per Victim ($)	Net Direct Cost ($)
1	1,601	811	790
2	3,442	1,354	2,088
3	8,089	2,120	5,969
4	18,467	2,865	15,602
5	138,684	2,845	135,839
6	18,294	3,406	14,888

The direct cost (net of property damage) and the indirect cost per A-B-C injury can be calculated by using these net direct costs for MAIS-1 to MAIS-6 and the indirect costs in Table 1, along with the weights in Table 9. For those MAIS-0 that were coded as injuries on the A-B-C scale, direct and indirect costs of zero are used. (A cost of zero is used for MAIS-0 because no empirical information is available on direct or indirect costs associated with accidents coded as injury accidents but that turn out to be MAIS-0, that is, PDO accidents. Although there may be some costs associated with such accidents, so that positive values should be used with the MAIS-0 weight in Table 9, precisely what values would be appropriate is unclear. In any event, the costs of A, B, and C injuries are not significantly affected by using a zero cost instead of some positive values.) Multiplying the weights by the MAIS costs and dividing the sum of the products by the sum of the weights (expressed as a proportion rather than as a percentage) produces direct and indirect costs of A, B, and C injuries.

TABLE 8 Percentage Distributions of Injuries by A-B-C and MAIS Severities by Accident Severity

A-B-C Cumulative Percentages	MAIS Percentages							
	0	1	2	3	4	5	6	Total[a]
Fatal accident								
C	0.42	10.96	1.80	1.24	0.48	0.00	0.00	14.90
B and C	0.60	29.00	9.50	7.33	2.22	0.39	0.00	49.04
A and B and C	0.60	38.75	20.12	23.71	10.51	6.01	0.30	100.00
Injury accident								
C	2.92	35.76	3.35	0.94	0.05	0.00	0.00	43.02
B and C	3.32	63.80	11.06	4.15	0.46	0.18	0.00	82.97
A and B and C	3.37	68.91	17.00	8.46	1.65	0.58	0.03	100.00

[a]Derived from Table 7.

TABLE 9 Weights for Converting MAIS Costs to A-B-C Costs per Injury

A-B-C Category and Accident Severity	MAIS Percentages (Weights)							
	0	1	2	3	4	5	6	Total[a]
Fatal accident								
A	0.00	9.75	10.62	16.38	8.29	5.62	0.30	50.96
B	0.18	18.04	7.70	6.09	1.74	0.39	0.00	34.14
C	0.42	10.96	1.80	1.24	0.48	0.00	0.00	14.90
Injury accident								
A	0.05	5.11	5.94	4.31	1.19	0.40	0.03	17.03
B	0.40	28.04	7.71	3.21	0.41	0.18	0.00	39.95
C	2.92	35.76	3.35	0.94	0.05	0.00	0.00	43.02

[a]Derived from Table 7.

The procedure can be illustrated by calculating the costs per A injury in a fatal accident. The net direct cost per A injury is estimated as

MAIS Injury	Weight (Table 9)	Net Direct Cost ($)	Product ($)
0	0.0000	0	0
1	0.0975	790	77
2	0.1062	2,088	222
3	0.1638	5,969	978
4	0.0829	15,602	1,293
5	0.0562	135,839	7,634
6	0.0030	14,888	45
Total	0.5096		10,249

Net direct cost = (Sum of products)/(Sum of weights) = ($10,249)/(0.5096) = $20,112 per A injury in a fatal accident.

The indirect cost per A injury is estimated as

MAIS Injury	Weight (Table 9)	Indirect Cost (Table 1) ($)	Product ($)
0	0.0000	0	0
1	0.0975	690	67
2	0.1062	1,165	124
3	0.1638	2,217	363
4	0.0829	32,564	2,700
5	0.0562	122,897	6,907
6	0.0030	724,227	2,173
Total	0.5096		12,334

Indirect cost = (Sum of products)/(Sum of weights) = ($12,334)/(0.5096) = $24,203 per A injury in a fatal accident.

The total cost per injury, net of property damage, is the sum of the indirect and net direct costs:

Net total cost = Net direct cost + Indirect cost = $20,112 + $24,203 = $44,315 per A injury in a fatal accident.

Net direct, indirect, and net total costs per injury are given in Table 10 for A, B, and C injuries in fatal accidents and in injury accidents.

COST PER NONFATAL INJURY ACCIDENT

The total cost per nonfatal injury accident can be estimated in either of two ways. The first approach is to use the net total costs of A, B, and C injuries (C_A, C_B, and C_C) in Table 10 and the average numbers of A, B, and C injuries per accident (A, B, and C) in Table 4, with an adjustment to include the average amount of property damage per injury accident. The net total cost per injury accident is estimated as the costs per injury in Table 10 times the respective numbers of A, B, and C injuries per accident in Table 4:

TABLE 10 Net Costs of A, B, and C Injuries in Fatal and Injury Accidents (1980 dollars)

Accident Severity and Type of Cost	Cost per Injury		
	A ($)	B ($)	C
Fatal			
Direct[a]	20,112	4,303	1,839
Indirect	24,203	4,086	1,876
Total[a]	44,315	8,389	3,715
Injury			
Direct[a]	6,783	2,213	972
Indirect	7,612	1,775	751
Total[a]	14,395	3,988	1,723

[a]Net of direct property damage costs.

Net total cost = $(C_A \times A) + (C_B \times B) + (C_C \times C)$

For injury accidents in rural and urban areas, the net total costs per accident are

Net total cost = ($14,395 x 0.3457) + ($3,988 x 0.5770) x ($1,723 x 0.6027) = $8,316 per rural injury accident.

Net total cost = ($14,395 x 0.1883) + ($3,988 x 0.5990) x ($1,723 x 0.6575) = $6,232 per urban injury accident.

The amount of property damage per injury accident is then added to the net total cost per accident to arrive at the total cost per nonfatal injury accident. The property damage per accident is equal to the average property damage per vehicle involved in injury accidents [$1,632 in 1980 dollars, based on Table VI-1 in the NHTSA Report (3)] times the average number of vehicles involved per injury accident in Table 2. The property damage cost per nonfatal injury accident in rural and urban areas is

Property damage cost = Cost per vehicle x Vehicles per accident = $1,632 x 1.4264 = $2,328 per rural injury accident.

Property damage cost = $1,632 x 1.5399 = $2,513 per urban injury accident.

The total cost per nonfatal injury accident is equal to the sum of the net total cost and the property damage per accident. For injury accidents in rural and urban areas, the total cost per accident is

Total cost = Net total cost + Property damage cost = $8,316 + $2,328 = $10,644 per rural injury accident.

Total cost = $6,232 + $2,513 = $8,745 per urban injury accident.

Alternatively, the total cost per injury accident can be estimated by explicitly calculating the direct and indirect costs per injury accident and then summing these two costs. The indirect cost per injury accident is readily estimated by multiplying the indirect costs of A, B, and C injuries from Table 10 (IC_A, IC_B, and IC_C) by the corresponding numbers of injuries per injury accident from Table 4 (A, B, and C) as follows:

Indirect cost = (IC_A x A) + (IC_B x B) + (IC_C x C) = ($7,612 x 0.3457) + ($1,775 x 0.5770) + ($751 x 0.6027) = $4,108 per rural injury accident.

Indirect cost = ($7,612 x 0.1883) + ($1,775 x 0.5990) + ($751 x 0.6575) = $2,990 per urban injury accident.

The net direct cost per injury accident is equal to the sum of the net direct costs of A, B, and C injuries from Table 10 (NDC_A, NDC_B, and NDC_C) times the corresponding numbers of A, B, and C injuries per injury accident from Table 4:

Net direct cost = (NDC_A x A) + (NDC_B x B) + (NDC_C x C) = ($6,783 x 0.3457) + ($2,213 x 0.5770) + ($972 x 0.6027) = $4,208 per rural injury accident.

Net direct cost = ($6,783 x 0.1883) + ($2,213 x 0.5990) + ($972 x 0.6575) = $3,242 per urban injury accident.

Net direct cost plus property damage per injury accident gives the direct cost per injury accident:

Direct cost = Net direct cost + Property damage cost = $4,208 + $2,328 = $6,536 per rural injury accident.

Direct cost = $3,242 + $2,513 = $5,755 per urban injury accident.

The total cost per nonfatal injury is equal to the sum of the direct and indirect costs:

Total cost = Direct cost + Indirect cost = $6,536 + $4,108 = $10,644 per rural injury accident.

Total cost = $5,755 + $2,990 = $8,745 per urban injury accident.

COST PER FATAL ACCIDENT

The total cost per fatal accident is derived from cost information reported by Miller et al. (1) for indirect costs and the NHTSA report (3) for direct costs and from the costs of A, B, and C injuries developed earlier. The indirect cost per fatal accident is readily obtained by multiplying the indirect cost per fatality in Table 1 and the indirect costs of A, B, and C injuries in Table 10 (IC_F, IC_A, IC_B, and IC_C) by the numbers of fatalities and A, B, and C injuries per fatal accident in Table 4, as follows:

Indirect cost = (IC_F x F) + (IC_A x A) + (IC_B x B) + (IC_C x C) = ($724,227 x 1.1516) + ($24,203 x 0.5315) + ($4,086 x 0.3173) + ($1,876 x 0.1396) = $848,442 per rural fatal accident.

Indirect cost = ($724,227 x 1.0862) + ($24,203 x 0.3528) + ($4,086 x 0.3015) + ($1,876 x 0.1298) = $796,670 per urban fatal accident.

The direct cost per fatal accident is estimated as follows. As with the net direct cost per injury, the direct cost per fatality of $18,294 in Table 1 is adjusted by deleting the average amount of property damage per victim, estimated to be $3,406 (1), to give a net direct cost per fatality of $14,888. The direct cost per fatal accident, net of property damage, is then estimated as the sum of the net direct costs per fatality and per A, B, and C injury in Table 10 (NDC_F, NDC_A, NDC_B, and NDC_C, respectively) times the corresponding average numbers of fatalities and A, B, and C injuries per fatal accident from Table 4 (F, A, B, and C, respectively):

Net direct cost = (NDC_F x F) + (NDC_A x A) + (NDC_B x B) + (NDC_C x C) = ($14,888 x 1.1516) + ($20,112 x 0.5315) + ($4,303 x 0.3173) + ($1,839 x 0.1396) = $29,457 per rural fatal accident.

Net direct cost = ($14,888 x 1.0862) + ($20,112 x 0.3528) + ($4,303 x 0.3015) + ($1,839 x 0.1298) = $24,803 per urban fatal accident.

The amount of property damage per fatal accident is equal to the property damage per vehicle involvement in fatal accidents, which is $3,760 from Table VI-1 in the NHTSA report (3), times the average number of involvements per fatal accident from Table 2:

Property damage = $3,760 x 1.3930 = $5,238 per rural fatal accident.

Property damage = $3,760 x 1.4316 = $5,383 per urban fatal accident.

The direct cost per fatal accident, then, is the sum of the net direct cost and the property damage cost:

Direct cost = Net direct cost + Property damage cost = $29,457 + $5,238 = $34,695 per rural fatal accident.

Direct cost = $24,803 + $5,383 = $30,186 per urban fatal accident.

The total cost per fatal accident is equal to the sum of the direct and indirect costs. For accidents in rural and urban areas, the total cost per fatal accident is

Total cost = Direct cost + Indirect cost = $34,695 + $848,442 = $883,137 per rural fatal accident.

Total cost = $30,186 + $796,670 = $826,856 per urban fatal accident.

Direct, indirect, and total costs per fatal, injury, and PDO accident in rural and urban areas are summarized in Table 11. Accident proportions by severity from Table 3 were used to obtain the average cost per rural accident and per urban accident.

UPDATING ACCIDENT COSTS

The accident costs in Table 11 can readily be updated from 1980 by applying appropriate cost indices to the direct and indirect costs. For updating the accident costs to 1985, suitable indices for direct and indirect accident costs are the consumer price index (CPI) for all items (equal to 247.0 in 1980

TABLE 11 Accident Costs by Area and Severity (1980 dollars)

Area and Type of Cost	Accident Cost by Severity			
	Fatal ($)	Injury ($)	PDO ($)	Average ($)
Rural				
Direct	34,695	6,536	1,096	3,715
Indirect	848,442	4,108	202	15,309
Total	883,137	10,644	1,298	19,024
Urban				
Direct	30,186	5,755	1,283	2,581
Indirect	796,670	2,990	236	4,562
Total	826,856	8,745	1,519	7,143

and 323.0 in 1985, third quarter, 1967 = 100.0) and the index of average hourly earnings (IAHE) (equal to 127.3 in 1980 and 165.9 in 1985, third quarter, 1977 = 100.0). The total accident cost for any severity and rural-urban area in Table 11 can be calculated as the sum of the 1980 direct and indirect costs multiplied by their respective increases from 1980 to 1985. For example, the updated average total cost of a rural accident is equal to ($3,715)(323.0/247.0) + ($15,309)(165.9/127.3) = $24,809. Although it would be more precise to first update the MAIS unit costs given by Miller et al. (1) to 1985 dollars and then develop 1985 costs per accident, the described procedure should yield reasonably accurate updates of the 1980 accident costs in Table 11.

SUMMARY AND CONCLUSIONS

In order for states to effectively allocate limited highway safety funds, a method such as benefit-cost analysis must be used. This generally requires accident costs for estimating the expected accident reduction benefits of safety improvements. Among the most recent attempts to provide comprehensive estimates of motor vehicle accident costs is a 1984 study by Miller et al. for FHWA (1) in which the apparently best available estimates were summarized. However, that study did not express accident costs in a form that can be directly used with state accident data in benefit-cost analyses.

In this paper, accident costs were developed from the cost data presented in the study by Miller et al. (1) and accident data from five states, employing methods previously developed in a study by McFarland and Rollins for FHWA (2). A major aspect of this paper was to relate the percentage distributions of injuries by the MAIS and A-B-C severity scales, thereby allowing the MAIS-based costs reported by Miller et al. (1) to be expressed in terms of A-B-C severities. The result of the analysis was a set of costs per accident, in terms of the A-B-C severity scale on which state accident data are commonly based. These accident costs can be used directly with state accident data, thereby facilitating the use of state-of-the-art accident cost estimates in benefit-cost analyses of highway safety improvements.

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