COMPREHENSIVE AND HUMAN CAPITAL CRASH COSTS BY MAXIMUM POLICE-REPORTED INJURY SEVERITY WITHIN SELECTED CRASH TYPES

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ABSTRACT

This paper presents estimates for both the economic and comprehensive costs per crash for three police-coded severity groupings within 16 selected crash types and within two speed limit categories (<=45 and >=50 mph). The economic costs are hard dollar costs. The comprehensive costs include economic costs and quality of life losses. We merged previously developed costs per victim keyed on the Abbreviated Injury Scale (AIS) into US crash data files that scored injuries in both the AIS and police-coded severity scales to produce per crash estimates. The most costly crashes were non-intersection fatal/disabling injury crashes on a road with a speed limit of 50 miles per hour or higher where multiple vehicles crashed head-on or a single vehicle struck a human (over 1.69 and $1.16 million per crash, respectively). The annual cost of police-reported run-off-road collisions, which include both rollovers and object impacts, represented 34% of total costs.

In conventional traffic safety intervention evaluations, the outcome measure is typically the frequency of police-reported crashes, often with separate estimates for different severity levels and crash types. However, some interventions may decrease some crash types but increase others. If these crash types are characterized by different average injury severities, then comparing crash frequencies will not provide the user with an accurate picture of intervention effectiveness. This problem led to the development of the crash cost estimates by crash type described in this paper.

A study of the red-light-camera (RLC) programs funded currently by Federal Highway Administration (FHwA) is a good example of this problem. Based on past literature, RLC programs can be expected to decrease angle-type crashes, but to increase rear-end crashes [Retting, Ferguson and Hakkert, 2002]. The former tends to be more severe than the latter, but less frequent. For that reason, the present study not only examines crash effects by type, but also includes crash severity in the analysis by converting each crash into an economic cost, based on unit costs by crash type and by police-reported severity, for crashes at urban signalized intersections.

Past studies have developed crash costs for the United States [e.g., Miller, Lestina, Galbraith et al., 1997; Wang, Knipling and Blincoe,1999; Zaloshnja, Miller, Romano et al., 2004]. Most of them estimate costs per person injured or vehicle damaged rather than cost per crash. Moreover, they often provide cost breakdowns by body region and, within that, by injury severity measured on the Abbreviated Injury Scale (AIS). AIS is specified by trained medical data coders, usually within a hospital context. It is not recorded on police crash reports, making these cost estimates unusable in the majority of safety studies conducted.

Miller et al. (1997) successfully linked crash costs to police-reported crash profiles for a number of crash scenarios by using data files that contained both AIS and police-reported severity. That study provided aggregate costs, not unit cost estimates by police-reported severity and crash type. It was intended to aid vehicle design that minimized overall harm. Wang et al. (1999) undertook a similar study, estimating unit costs by crash type and AIS for crashes that could be averted by Intelligent Transportation Systems (ITS) technologies. Andreassen (1992) provided similar costs for Australia.

Differently from previous studies, this paper provides unit and total costs by crash type and severity, and both economic cost estimates of hard dollar consequences and comprehensive cost estimates, which add a value of the non-monetary losses to the economic costs. Detailed estimates are provided for three police-reported crash severity groupings within 16 critical crash types (e.g., pedestrian crash at signalized intersection; multi-vehicle cross-path crash at signalized intersection) and within two speed limit categories

(<=45 mph and >=50 mph) to account for possible differences in costs for a given police-reported severity level between high-speed and low-speed crashes.

METHODS

Modeling crash costs requires estimates of the number of people involved in a crash, the medical details of each person's injuries (ideally, body part injured, nature of the injury, and injury severity, e.g,, skull fracture not resulting in loss of consciousness), and the costs of those injuries and associated vehicle damage and travel delay. The next section describes the methodology used to estimate the incidence and medical details of crash injuries for selected crash types and speed limits. The succeeding section explains how the costs of crashes were estimated.

ESTIMATION OF INJURY INCIDENCE AND MEDICAL DETAILS – No data system that contains a nationally representative sample of recent U.S. incidence data on non-fatal crash injuries records both crash type and medical descriptions of the injuries. The National Highway Traffic Safety Administration's (NHTSA's) National Accident Sampling System [NASS; NHTSA, 1987] collected data containing medical descriptions of injuries for a representative sample of all police-reported U.S. motor vehicle injury victims in 1984–1986. In 1988, NASS was replaced by two ongoing sampling systems. The Crashworthiness Data System [CDS; NHTSA, 2002a] collects data similar to NASS but focuses on crashes involving automobiles and automobile derivatives, light trucks and vans with gross vehicle weight less than 10,000 pounds (4,537 kg) that are towed due to damage, and eliminates pedestrian and non-motorist records. The General Estimates System (GES) collects data on a representative sample of all police-reported crashes, but the only injury description it gives is the severity that a police officer assigned in the police accident report.

GES, like the police reports, uses the KABCO severity scale [National Safety Council, 1990] to classify crash victims as K-killed, A-disabling injury, B-evident injury, C-possible injury, or O-no apparent injury. The codes are selected by police officers without medical training, typically without benefit of a hands-on examination. Some victims are transported from the scene before the police officer who completes the crash report even arrives. Thus, police reporting does not accurately describe injuries medically. Moreover, KABCO ratings are coarse and inconsistently coded between states and localities and over time [Miller, Viner, Rossman et al., 1991, Blincoe and Faigin, 1992, O'Day, 1993]. Viner and Conley (1994) found one cause of this variability was differing state definitions of A-injury. Miller et al. (1987) found police-reported injury counts by KABCO severity systematically varied between states because of differing state crash reporting thresholds (the rules governing which crashes should be reported to the police) and that state reporting thresholds often changed over time. GES verifies that all crash deaths are coded as K and all crash victims coded as K died.

NASS and CDS record both the KABCO codes assigned by police and medical descriptions of injury in the Occupant Injury Coding system (OIC). OIC codes include detailed medical descriptions plus AIS threat to life severity scores. The NASS data were coded with the 1980 version of OIC/AIS, which differs slightly from the 1985 version; but NHTSA made most OIC/AIS-85 changes well before their formal adoption (AAAM, 1985). The 1999–2001 CDS data used in this paper were coded in AIS-90 (AAAM, 1990).

Starting with Miller et al. (1997), NHTSA's past costing studies and ours have met the challenge posed by the lack of an adequate data system by simulating the records that CDS would have collected if it had sampled the non-CDS strata (i.e., injuries to passenger vehicle occupants involved in non-tow-away crashes and to pedestrians, pedalcyclists, and heavy vehicle occupants). Combining the simulated data with the actual CDS data yields a synthesized, nationally representative sample of crashes with both crash types and medical descriptions of the injuries of all people involved in the crashes.

Our simulation used 1999–2001 GES data to reweight the 1984–1986 NASS data for the non-CDS strata so they represent the average annual estimated GES injury victim counts in non-CDS crashes. In applying the GES weights, we controlled for crash type (as defined by geometry), police-reported injury severity, speed limit (<=45 miles per hour (mph) and >=50 mph), and restraint use. For example, if GES had 20,000 weighted non-CDS cases where belted occupants experienced an A injury after the vehicle they were in struck animals on roads with speed limits of 50 mph and over and NASS had 10,000 weighted cases, we would multiply the NASS weights for these cases times 20,000/10,000. Weighting the NASS data to GES restraint use levels updates the NASS injury profile to a profile reflecting contemporary belt use levels. This procedure assumes that particular crash types generate typical profiles of injury outcomes that are stable over time, an assumption that Australian research supports [Andreassen, 1986]. Sample size considerations drove the decision to pool and average 3 years worth of GES data.

At the completion of the weighting process, we combined the CDS data with the synthesized NASS data on the non-CDS strata. This hybrid file was comprised of 1999–2001 CDS records for non-heavy vehicle, tow-away crashes and of reweighted 1984–86 NASS records for all other crashes. Finally, we adjusted the weights on fatal crashes in both CDS and non-CDS strata so that the weighted counts by strata, crash geometry and speed limit matched the fatal crash counts in NHTSA's Fatality Analysis Reporting System [FARS; NHTSA, 2002b]. This file became our study's incidence file.

Crash geometry was grouped into 16 categories. The categories were constructed based on the information found in three fields of NHTSA's data files: Manner of Collision; Relation to Junction; and Traffic Control Device. Crash severity was grouped into three severity categories (O, B/C, and A/K). We grouped the data because the sample size by severity code was too small to yield accurate distributions of the medical descriptions of injuries for some severities by geometry; corresponding mean costs at that level of detail would be unreliable, and a few crashes might bias the results.

COST ESTIMATION - The second step required to estimate average crash costs is to generate estimates of crash costs by severity. We adopted these costs from Zaloshnja et al. (2004). That article gives costs per victim in 2000 dollars by body part, whether or not a fracture was involved, and AIS (for both AIS85 and AIS90). We updated the costs to 2001 dollars and merged them onto the hybrid CDS/NASS/FARS file. Comprehensive costs represent the present value, computed at a 4% discount rate, of all costs that result from a crash over the victim's expected life span. We chose this discount rate in order to be consistent with NHTSA's and FHwA's methodology. We also conducted a sensitivity analysis with two other discount rates (3% and 7%). We included the following major categories of costs: (1) medically related, (2) emergency services, (3) property damage, (4) lost productivity (wage and household work), and (5) the monetized value of pain, suffering, and lost quality of life. Together, the literature calls these comprehensive costs. Economic costs exclude the last item.

Zaloshnja et al.'s (2004) medical cost estimates drew on data from 1992–1994 Civilian Health and Medical Program of the Uniformed Services (CHAMPUS) data for physician and emergency department fees, 1994–95 data on hospital costs in MD and NY (the only two states where costs, not charges or payments were known), and 1987 National Medical Expenditure Survey (NMES) and 1979–1987 National Council on Compensation Insurance (NCCI) data on the percentage of costs that occur more than 6 months post injury.

Zaloshnja et al. (2004) based short-term productivity loss on information from the CDS 1988–1991(for AIS85) and CDS 1993–1999 (for AIS90) about the probability an employed person would lose work for a specific injury and the 1993 Survey of Occupational Injury and Illness (SOII) of the U.S. Bureau of Labor Statistics on the days of work lost per person who lost work. Mean probabilities of work loss were estimated from just those CDS records that had the relevant information, which frequently was missing. Sample size considerations drove the decision to pool several years of CDS data.

Long-term productivity loss by diagnosis was based on 1979–1987 NCCI Detailed Claims Information (DCI) data on the probability that injuries would cause permanent partial/total disability and 1997 DCI data on the percentage loss of earning power for partially disabled injury victims.

Zaloshnja et al. (2004) included a variety of other direct costs. Among them were emergency services, property damage, travel delay, insurance claims administration, legal and court costs, and workplace disruption costs. These estimates used insurance data, recent data on travel delay that crashes cause motorists whose vehicles did not crash, and data from prior NHTSA studies.

Following Miller, Pindus, Douglass et al. (1995), Zaloshnja et al. (2004) based quality of life loss on physicians' estimates of the functional capacity lost over time by injury diagnosis and a systematic review of the survey literature on the loss in value of life that results from different functional losses. These losses were costed based on a meta-analysis examining what people pay for small changes in fatality risk and surveys on what they state they are willing to pay.

COSTS PER CRASH - To compute costs per crash for the non-CDS strata, from the reweighted, costed NASS non-CDS person-level file, we tabulated total costs by crash geometry, speed limit, and the maximum KABCO severity in the crash, then divided by the corresponding GES crash counts for the non-CDS strata. Mean costs for the CDS and non-CDS strata than were averaged to arrive at overall mean costs.

VARIANCE ESTIMATION - To estimate standard errors and confidence intervals we used STATA 7. The procedure "svymean" in STATA 7 is designed specifically to estimate standard errors and confidence intervals for complex survey data. It takes into account the stratification (strata) and clustering (PSUs) used in the survey. Our hybrid NASS/CDS/FARS file was treated as a single survey with three different strata: tow-away, not-tow-away, and pedestrian/pedalcyclist crashes.

We were not able to measure the variance of unit cost elements like medical costs, property damage, emergency services, travel delay, insurance administration, etc. Therefore standard errors represent the variance in crash costs caused by differences in the number of people involved in crashes of the same type, the severity of injuries suffered (as described by AIS, body part, and fracture status of the injury), and the age and sex of the victims (critical for estimating the magnitude of productivity and quality of life loss, because those estimates are based on life-time expected earnings and life expectancy tables by age and sex).

RESULTS

Figures 1 and 2 display the estimates of cost per crash, as well as their standard errors. They also show the number of raw and weighted cases used to compute each estimate. Estimates for injury crashes that are based on less than 20 cases should be used cautiously because too few cases are available for the diagnosis distribution underlying them to be very accurate. More detailed unit cost estimates for individual KABCO levels will be available from FHwA in the near future.

Figure 1 describes single-vehicle crashes. Figure 2 describes multi-vehicle crashes. For any given crash type, predictably, K+A crashes cost more than B+C crashes, which in turn cost more than O crashes. The most costly crashes were non-intersection fatal/disabling injury crashes on a road with a speed limit of 50 miles per hour or higher where multiple vehicles crashed head-on or a single vehicle struck a human.

Figure 1. Costs per Police-Reported, Single-Vehicle Crash by Type, Speed Limit, and KABCO – United States, 1999–2001 (in 2001 dollars)

Crash type	Intersection information	Speed limit (mph)	Maximum severity in crash	Obs.	Weighted count	Mean comprehensive cost per crash	Std. err.	Mean economic cost per crash	Std. err.
Vehicle struck human	Intersection	<=45	O	31	1,013	10,249	1,408	8,512	997
			B/C	515	28,002	59,681	8,967	33,091	4,547
			K/A	401	7,466	489,873	41,417	211,470	15,234
		>=50	O	5	3,441	4,015	1,511	3,672	1,141
			B/C	35	10,586	155,975	98,422	81,906	52,153
			K/A	17	3,577	780,749	341,436	283,148	100,143
	No intersection	<=45	O	33	103	40,428	27,351	28,370	18,026
			B/C	721	19,300	71,085	7,273	39,128	3,372
			K/A	733	8,078	698,999	52,933	260,171	16,898
		>=50	O	18	7,212	2,831	175	2,797	145
			B/C	54	11,746	54,133	16,159	30,842	7,880
			K/A	121	4,135	1,162,196	186,613	402,438	53,583
Vehicle struck animal	Anywhere	<=45	O	10	14,660	2,617	0	2,617	0
			B/C	3	366	89,287	67,282	37,280	24,752
			K/A	3	118	96,055	26,210	67,137	14,691
		>=50	O	61	78,540	5,619	2,661	4,904	2,047
			B/C	18	2,580	22,832	7,622	14,205	3,467
			K/A	20	954	165,302	40,911	76,781	20,958
Vehicle struck object	Anywhere	<=45	O	608	164,345	5,721	1,195	4,835	1,016
			B/C	446	71,211	65,714	5,964	33,975	2,463
			K/A	773	19,999	492,367	109,816	193,164	43,396
		>=50	O	618	308,154	5,565	428	4,513	298
			B/C	688	159,298	62,470	9,449	31,148	4,174
			K/A	1,717	76,194	479,838	100,761	195,490	37,079
Vehicle struck parked vehicle	Anywhere	<=45	O	161	82,847	3,738	407	3,438	278
			B/C	59	12,941	28,182	6,433	17,436	3,049
			K/A	67	1,703	241,364	77,310	106,163	32,795
		>=50	O	25	43,292	6,223	1,364	5,288	462
			B/C	32	5,678	52,439	11,793	26,292	4,865
			K/A	57	1,260	457,353	200,952	182,592	67,349
Rollover	Anywhere	<=45	O	31	2,133	9,697	1,398	6,940	806
			B/C	147	19,986	57,521	6,362	30,996	2,922
			K/A	151	6,233	355,920	141,354	140,176	49,761
		>=50	O	89	40,380	13,526	5,772	8,798	3,583
			B/C	247	65,248	70,675	19,907	36,370	9,516
			K/A	575	25,941	855,006	90,191	310,101	31,322

Figure 2. Costs per Police-Reported Multiple-Vehicle Crash, by Type, Speed Limit, and KABCO – United States, 1999–2001 (in 2001 dollars)

Crash type	Intersection information	Speed limit (mph)	Maximum severity in crash	Obs.	Weighted count	Mean comprehensive cost per crash	Std. err.	Mean economic cost per crash	Std. err.
Cross-path collision	Signalized intersection	<=45	O	1,043	248,744	8,673	1,285	7,503	925
			B/C	625	66,280	46,660	11,847	29,271	6,547
			K/A	343	7,940	213,113	44,733	96,057	17,573
		>=50	O	301	134,748	8,544	1,294	6,735	863
			B/C	636	138,306	53,195	5,794	29,636	2,959
			K/A	926	38,301	392,949	118,813	155,748	43,945
	Signed intersection	<=45	O	773	162,344	7,910	1,255	6,574	724
			B/C	463	76,233	48,035	10,156	28,436	4,701
			K/A	341	6,953	441,901	112,658	188,771	42,447
		>=50	O	194	107,893	5,444	1,265	4,797	975
			B/C	328	73,421	77,886	10,157	43,234	5,109
			K/A	530	22,712	593,866	104,565	229,032	37,727
	Unsigned intersection	<=45	O	244	116,399	5,604	471	5,257	366
			B/C	153	33,221	32,708	5,017	21,012	2,879
			K/A	79	4,640	220,991	79,947	113,013	38,489
		>=50	O	69	95,652	7,920	2,000	6,708	1,456
			B/C	108	27,192	66,026	11,270	35,837	6,324
			K/A	152	4,488	572,280	91,308	245,301	42,427
Rear-end collision	Signalized intersection	<=45	O	492	86,871	11,463	3,338	9,454	2,295
			B/C	418	42,581	39,398	8,202	26,255	4,476
			K/A	90	5,611	84,820	19,977	43,601	10,054
		>=50	O	142	33,373	5,901	1,082	4,810	671
			B/C	165	38,738	32,761	8,592	19,658	4,724
			K/A	127	5,734	184,104	79,930	77,797	27,435
	Signed intersection	<=45	O	99	145,318	12,295	4,622	10,586	3,540
			B/C	50	2,860	46,644	16,047	25,003	4,819
			K/A	22	377	127,706	39,338	71,190	18,954
		>=50	O	18	5,407	3,788	978	3,302	549
			B/C	14	925	15,268	2,002	11,759	1,367
			K/A	7	143	159,658	57,481	88,088	29,294
	No intersection	<=45	O	903	222,988	5,756	269	5,516	176
			B/C	506	219,333	26,642	3,940	18,630	2,479
			K/A	182	4,326	267,844	129,536	119,894	56,253
		>=50	O	771	539,780	10,972	2,319	9,055	1,556
			B/C	600	95,074	88,498	33,108	43,717	12,936
			K/A	448	23,428	452,624	134,484	162,582	45,649
Sideswipe	Anywhere	<=45	O	1,658	434,489	6,007	416	5,679	330
			B/C	590	57,107	51,211	11,817	30,396	7,243
			K/A	350	8,991	222,564	51,456	92,479	16,725
		>=50	O	681	294,467	5,762	348	5,218	211
			B/C	506	101,900	68,009	8,958	37,641	4,667
			K/A	698	32,940	483,204	135,764	182,885	47,686
Head-on collision	Signalized intersection	<=45	O	42	9,195	5,101	245	5,053	229
			B/C	18	430	119,622	11,151	67,648	9,797
			K/A	8	160	239,933	93,666	141,744	52,759
		>=50	O	2	473	2,617	-	2,617	-
			B/C	2	795	29,181	810	19,761	312
			K/A	12	301	360,354	130,323	204,874	45,975
	Signed intersection	<=45	O	10	1,883	4,806	399	4,793	407
			B/C	3	454	27,351	2,224	20,809	1,666
			K/A	4	135	73,751	23,281	43,138	10,083
		>=50	O	4	928	6,169	3,363	5,027	2,281
			B/C	7	1,036	74,466	26,605	44,684	13,502
			K/A	10	157	659,591	351,717	225,249	107,412
	No intersection	<=45	O	55	14,675	3,948	739	3,830	703
			B/C	55	9,653	40,463	9,495	25,137	4,715
			K/A	81	1,940	605,328	224,211	250,035	81,522
		>=50	O	25	15,510	3,471	510	3,272	396
			B/C	51	6,562	126,409	18,294	72,561	11,836
			K/A	350	12,345	1,692,450	281,255	605,568	89,412

The most costly B+C crashes are for a single vehicle striking a human at an intersection on a high-speed road and for head-on crashes at non-intersections on high-speed roads or at signalized intersections on low-speed roads. In viewing the costs for crashes the police code as "property damage only," it is important to realize that many actually involve minor and occasionally even major injuries [Miller et al., 1991]. The most costly O crashes are crashes where a human was struck at non-intersections on low-speed roads and rear-end crashes (which may result in whiplash injuries that are asymptomatic at the scene and therefore coded as O in police reports).

Figure 3 shows that the annual comprehensive and economic costs of police-reported crashes in the US during 1999–2001 were $346 billion and $164 billion respectively. Over 93% of the total annual cost comes from crash categories reported in this figure. The remaining costs come from other types of crashes (e.g. crashes between vehicles while backing) or crashes for which we did not have information on any of the relevant variables.

Figure 3. Aggregate Annual Costs of Police-Reported Crashes by Type and Speed Limit – United States, 1999–2001 (in 2001 billion dollars)

Crash type	Intersection information	Speed limit (mph)	Annual comprehensive cost	Std. err.	Anual economic cost	Std. err.
Vehicle struck human	Intersection	<=45	6.0	0.7	2.7	0.3
		>=50	2.7	0.9	1.3	0.5
	No intersection	<=45	8.9	0.7	3.4	0.3
		>=50	6.4	1.2	2.3	0.4
Vehicle struck animal	Anywhere	<=45	0.1	0.0	0.1	0.0
		>=50	0.7	0.3	0.5	0.2
Vehicle struck object	Anywhere	<=45	20.6	4.7	8.9	1.9
		>=50	60.0	18.0	24.8	7.2
Vehicle struck parked vehicle	Anywhere	<=45	2.1	0.4	1.2	0.2
		>=50	1.8	0.5	0.8	0.2
Rollover	Anywhere	<=45	4.2	1.6	1.8	0.6
		>=50	34.3	10.7	12.9	3.7
Cross-path collision	Signalized intersection	<=45	7.5	1.5	4.9	1.0
		>=50	23.7	4.6	11.1	2.1
	Signed intersection	<=45	8.5	1.4	4.8	0.7
		>=50	20.1	5.1	9.1	2.1
	Unsigned intersection	<=45	2.9	0.7	1.9	0.4
		>=50	5.1	1.1	2.7	0.5
Rear-end collision	Signalized intersection	<=45	3.8	0.7	2.6	0.5
		>=50	2.6	0.6	1.4	0.3
	Signed intersection	<=45	2.0	1.3	1.7	1.1
		>=50	0.1	0.0	0.0	0.0
	No Intersection	<=45	8.8	2.9	6.2	2.2
		>=50	25.6	6.2	13.2	3.6
Sideswipe	Anywhere	<=45	8.7	1.2	5.8	0.8
		>=50	25.1	3.9	11.8	1.8
Head-on collision	Signalized intersection	<=45	0.2	0.1	0.1	0.0
		>=50	0.1	0.1	0.1	0.0
	Signed intersection	<=45	0.0	0.0	0.0	0.0
		>=50	0.2	0.1	0.1	0.0
	No Intersection	<=45	1.6	0.6	0.8	0.3
		>=50	21.8	6.7	8.0	2.5
SUBTOTAL			323	52	153	20
Other/unknown			23	4	11	2
TOTAL			346	57	164	23

Figure 3 indicates that high-speed, single-vehicle crashes in which objects were struck placed the highest burden on society in 1999–2000; they generated annual comprehensive costs of $60 billion. Rollover crashes were a distant second at over $34 billion annually.

The sensitivity analysis provided in Figure 4 indicates that the per crash and total cost estimates fall as the discount rate rises. Changing from a 4% to a 3% discount rate raises the comprehensive costs by 4.5% and the economic costs by 4.9%. Changing to a 7% discount rate reduces comprehensive costs by 6.7% and economic costs by 7.9%. The quality-of-life costs also will vary in proportion to the value of fatal risk reduction that underlies them.

Figure 4. Police-Reported Crash Costs at Different Discount Rates – US 1999–2001 (in 2001 dollars)

Cost Type	Discount rate	Per crash	Std. err.	Annual (billions)	Std. err.
Comprehensive	4%(base)	57,543	8,110	346	57
	3%	60,147	8,403	362	59
	7%	54,735	7,895	329	55
Economic	4%(base)	27,275	2,995	164	23
	3%	29,093	3,272	175	25
	7%	25,125	2,717	151	21

DISCUSSION

This paper provides cost estimates useful for evaluating ITS countermeasures, designing vehicles to minimize crash harm, and treating roadways to reduce specific types of crashes, sometimes with the side effect of increasing other crash types. It gives unit costs of crashes by type in the coding system used by the police. The costs represent 93% of all US crash costs and are in an appropriate form for economic analysis of countermeasures addressing locally defined problems identified by analyzing police crash reports.

LIMITATIONS – Limitations of this study are: (1) The reweighting of 1984–86 NASS data (non-CDS strata) was based on the assumption that the accuracy of police crash reporting has not changed since 1986. The literature sheds no light on this assumption. (2) In the non-CDS strata, our procedures underestimate by an unknown amount the costs for injured crash victims who police incorrectly reported as belted. (3) It does not include unreported crashes. Information about crash geometry for such crashes is not available in NHTSA data sets. (4) The number of crashes available as a basis for estimating the costs for some crash types is small. (5) The costs necessarily incorporate all the limitations of the underlying cost estimates. Foremost among those are reliance on old data for some cost components, use of inferred costs for a few types of injuries for which no cost data were available, and the assumption that cost data on working age adults accurately represent costs for children and the elderly.

The standard errors around the cost estimates are the first ever computed for US crash costs. They vary with both sample size and the variability of the crashes in a specific category. Nevertheless, they are imperfect. The lowest variance, for example, was for low-speed animal strikes that the police coded as property damage only. Consistent with the police coding, none of the 10 actual crashes caused any occupant injuries. Since our unit costs, like virtually all published US crash costs, are modeled, not measured, that means the estimated cost for each of the 10 crashes was identical and the variance was 0.0. In reality, costs for each crash undoubtedly varied from the mean. This is a serious shortcoming of the estimated standard errors. In the future, it would be desirable, although quite costly, to validate modeled unit costs by tracking a cohort of injury victims. A question that requires further debate among statisticians is how well a statistical package like STATA accommodates variance estimation for studies like ours that synthesize survey data.

USES OF THE ESTIMATES – These cost estimates could be used in a number of ways, ranging from estimating safety benefits for a proposed or implemented intervention for a given location or driver subpopulation to better defining high-priority targets for a state or national safety program. Figure 3 is an example analysis of priority targets. It estimates annual societal costs by crash type, both in terms of comprehensive costs and economic costs. This information could be one input in targeting safety program implementation funding or further intervention-development research efforts.

Summing across speeds, the largest annual comprehensive costs occur in run-off-road collisions, which include both rollovers and object impacts ($119 billion total), cross-path collisions ($68 billion), rear-end collisions ($50 billion), sideswipe collisions ($34 billion) and pedestrian crashes ($24 billion). Perhaps the only "surprise" in this list is the sideswipe collisions. All of the other crash types have been identified as priority areas under one or more FhwA or NHTSA programs related to roadway or vehicle improvements. Most of these crash types are also emphasis areas in the American Association of State Highway and Transportation Officials (AASHTO) Strategic Highway Safety Plan. (NHTSA and FHwA emphasis programs related to occupant restraint usage, excessive speed, and impaired driving would affect almost all of these crash types, and probably would emerge as high priorities if the initial data categorization was on driver actions rather than crash types.)

Figure 3 also identifies areas with high potential for intervention within crash types and speed limit categories. For example, the higher cross-path crash costs are seen at signalized intersections, particularly high-speed ones, and at high-speed (presumably rural) stop-sign controlled intersections. There is current emphasis on both roadway programs (e.g., red-light-camera enforcement) and vehicle programs (e.g., vehicle-based gap sensors) to treat these problems. These data indicate that perhaps more emphasis should be placed on the higher-speed (presumably rural) problems. The data also support more analysis of issues within the non-intersection pedestrian subset, the sideswipe subset, the non-intersection rear-end subset, and the high-speed non-intersections head-on subset. Such analyses could more clearly define the causal effects for these crash types and, thus, potential interventions.

This first-level analysis of crash cost is clearly not the only factor that should be used to determine safety program direction. In addition to this problem size data, one must consider the probability of successfully developing a usable intervention or policy change. Certain crash types (e.g., high-speed head-on crashes) have high costs but are more difficult to treat effectively than other high-cost types. The goal is to maximize the effects of limited research and implementation funding, so return on investment is critical to targeting. However, analysis such as this can clearly point in directions that warrant further study. Such analyses are now possible with the detailed crash costs developed in this effort.

ACKNOWLEDGEMENT

This work was performed under a contract from the FHwA. All aspects of the paper represent the views of the authors but not necessarily of the funding agency.

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