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TRAFFIC SAFETY FACTS
Research Note

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Estimating Lives and Costs Saved by Motorcycle Helmets With Updated Economic Cost Information

Summary

In 2013, an estimated 1,630 lives were saved in the United States by motorcycle helmets; an estimated 715 additional fatalities could have been prevented if all motorcyclists[1] had worn helmets. The lives saved resulted in an estimated $2.8 billion saved in economic costs, and $17.3 billion in comprehensive costs,[2] by helmet-wearing motorcyclists. An additional $1.1 billion could have been saved in economic costs, and $7.2 billion in comprehensive costs, if all motorcyclists had worn helmets.

The National Highway Traffic Safety Administration annually provides information on the number of lives saved by the use of DOT-compliant motorcycle helmets, as well as the potential number of lives that could have been saved at 100-percent helmet use. In addition, the economic costs saved by those wearing helmets, and how much could have been saved had all riders worn helmets, are also estimated. This information is provided for each State as well as the nation as a whole. A recently published report, *The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised)* (Blincoe, Miller, Zaloshnja, & Lawrence, 2015), updated the cost information used with these estimates.

This Research Note provides information on how NHTSA determines estimates of lives and costs saved by the use of motorcycle helmets, principally presenting updated economic cost estimate data. The Appendix details the process for calculating these estimates.

Background

The process NHTSA uses to calculate these estimates is detailed in *Determining Estimates of Lives and Costs Saved by Motorcycle Helmets* (NHTSA, 2011). The cost information in that document came from a number of reports published more than a decade ago (Blincoe, 1994; NHTSA, 1988; and Blincoe, Seay, Zaloshnja, Miller, Romano, Luchter, & Spicer, 2002). The information in these documents has recently been combined and updated in Blincoe, Miller, Zaloshnja, and Lawrence (2015), which provides not only updated economic cost estimates, but also cost estimates relating to lost quality of life. The combined economic and quality of life costs are referred to as "Total Costs" or "Comprehensive Costs." This new economic data enables an update of the procedure used to estimate the lives and costs saved by wearing motorcycle helmets, and the lives and costs that could be saved at 100-percent helmet use. The report of Blincoe and colleagues (2015) provides costs associated with various types of crashes (e.g., police reported/unreported, crashes that involve speeding, crashes involving bicyclists, costs that occurred as a result of crashes and costs saved due to safety equipment use).

Methodology

NHTSA's National Center for Statistics and Analysis (NCSA) published *Calculating Lives Saved by Motorcycle Helmets* (Deutermann, 2005) that presented the formulas and calculations for estimating the number of lives saved by motorcycle helmets. While this document was published in 2005, the effectiveness estimates (37% for riders [operators] and 41% for passengers) and method remains current.

NHTSA's methodology to estimate the number of motorcyclists saved by helmets, and the associated costs, is based on the number of motorcyclist fatalities. Using the effectiveness estimates of motorcycle helmets and the number of motorcyclist fatalities, the number that would have died but were saved because they wore a helmet can be calculated. The number of fatalities is obtained from the Fatality Analysis Reporting System (FARS) database, a census of all traffic fatalities in the United States. Motorcyclists whose injuries were prevented by helmets, as well as those that could have been prevented, are calculated in a similar manner.

[1] Motorcyclist is the term used to reference both the motorcycle rider (operator) and the motorcycle passenger.

[2] The economic or human capital costs represent the tangible losses resulting from motor vehicle crashes, the value of resources that are used or that would be required to restore crash victims, to the extent possible, to their pre-crash physical and financial status. These are resources have been diverted from other more productive uses to merely maintain the status quo. These costs include medical care, lost productivity, legal and court costs, insurance administrative costs, workplace costs, travel delay, and property damage. Comprehensive costs are made up of these economic costs plus the estimated costs associated with lost quality of life. In cases of serious injury or death, medical care cannot fully restore victims to their pre-crash status, and the human capital costs fail to capture the relatively intangible value of lost quality-of-life that results from these injuries. In the case of death, victims are deprived of their entire remaining lifespan. In the case of serious injury, the impact on the lives of crash victims can involve extended or even lifelong impairment or physical pain, which can interfere with or prevent even the most basic living functions.

For every motorcyclist traffic fatality, a number of other motorcyclists receive injuries of various levels. Helmets are effective at preventing injuries as well as fatalities, and these must also be accounted for when calculating the economic costs prevented by helmets. Because NHTSA does not have data on the number and severity of motorcyclists injured in each State, the number of motorcyclists receiving serious and minor injuries are estimated, based on the number of fatalities in each State.

Previously, NHTSA economic estimates (Blincoe et al., 2002) used the year 2000 as the base year for economic estimates, and adjusted for inflation. Blincoe, Miller, Zaloshnja, and Lawrence (2015) updated this using 2010 as the cost base year. A change in the relative frequency of the levels of injury severity was also introduced. In the 2011 NCSA report, the estimated injuries were categorized into two groups based on their Maximum Abbreviated Injury Score (MAIS): minor (MAIS 1), which made up 63 percent of motorcyclist injuries, and serious (MAIS 2 through 5), which made up the remaining 37 percent. Blincoe, Miller, Zaloshnja, and Lawrence's report (2015) provides frequency estimates for each individual MAIS injury level, rather than grouping those who were seriously injured. This enables the estimation of the number of injured people at each individual MAIS level, rather than grouping MAIS levels 2 through 5. Note that because there are not effectiveness estimates for each MAIS level, the total estimate of the number of motorcyclists prevented from being injured does not change. The benefit is that the costs saved and savable can now be estimated more precisely. Finer detail on the distribution of injuries enables more accurate estimates of costs saved by the wearing of motorcycle helmets.

Note that:

- Costs that were prevented by the use of motorcycle helmets *would* have occurred had the motorcyclists not worn helmets.
- Preventable costs were those that *did* occur, but could have been prevented by the use of helmets. Since they are costs that were experienced, these preventable costs are a portion of the estimated reported cost of motorcyclist crashes.

Table 1 shows the estimated relative incidence of each injury level for reported motorcyclist crashes, separately by helmet use.

Table 1
Relative Injury Incidence in Reported Crashes, by Helmet Use

MAIS Level	Helmeted	Unhelmeted
1	0.64	0.62
2	0.22	0.23
3	0.12	0.14
4	0.01	0.01
5	0.01	0.01

Source: The economic and societal impact of motor vehicle crashes, 2010 (Revised) [Note: Shown are rounded values, obtained from the incidence of motorcyclists at each injury level in Tables 10-4 and 10-5.]

NHTSA has estimated that the effectiveness of helmets in preventing fatalities is 0.37 for riders and 0.41 for passengers (Deutermann, 2005). While there are not different effectiveness estimates for riders and passengers that are injured, there are two separate estimates based on the level of injury. NHTSA estimates helmets are 8 percent effective in preventing minor/MAIS 1 injuries, and 13 percent effective in preventing serious/MAIS 2 – 5 injuries (NHTSA, 1988). This latter estimate was developed using data from combined AIS 2 through 5 injured motorcyclists. Separate estimates of the effectiveness of motorcycle helmets in preventing each individual level of MAIS 2 through 5 injured motorcyclists have not been developed.

Another feature of the new method is that estimates of costs due to lost quality of life were added (Blincoe, Miller, Zaloshnja, & Lawrence, 2015). Previous cost estimates had included economic costs only. Using this new information, both economic and comprehensive (economic plus quality of life) costs are able to be provided.

Finally, cost estimates are available for non-fatally injured motorcyclists by helmet use. Even within an MAIS level, those injured who were unhelmeted have higher estimated costs than those who were helmeted, both economic and comprehensive. The differences are greater at higher injury levels. For fatalities, however, the economic and comprehensive costs are the same regardless of helmet use. The economic and comprehensive costs per injury level/fatality, by helmet use, are in Table 2. These values are those that appear in Blincoe, Miller, Zaloshnja, and Lawrence (2015) in 2010 dollars. For subsequent data years, these values are adjusted for inflation (see Appendix, Economic Impact).

Table 2
Economic and Comprehensive Unit Costs per Injured Motorcyclist, by Injury Level and Helmet Use, 2010

Helmet Use	Injury Level	2010 Costs	
		Unit Economic Cost	Unit Comprehensive Cost*
Helmeted	MAIS 1	$18,079	$30,915
	MAIS 2	$48,186	$220,580
	MAIS 3	$184,941	$759,107
	MAIS 4	$328,872	$1,701,424
	MAIS 5	$1,190,011	$4,909,241
	Fatal	**$1,381,645**	**$9,090,622**
Unhelmeted	MAIS 1	$18,941	$32,926
	MAIS 2	$49,258	$227,273
	MAIS 3	$184,639	$763,673
	MAIS 4	$352,587	$1,852,270
	MAIS 5	$1,617,283	$7,564,608
	Fatal	**$1,381,645**	**$9,090,622**

Source: *The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised)*, Tables 10-6 and 10-7.
*Comprehensive costs consist of Economic and Lost Quality-of-Life Costs.

It is important to note the differences between the Blincoe, Miller, Zaloshnja, and Lawrence (2015) cost report and the costs presented in this research note. Most importantly, costs covered in this research note relate specifically to those costs prevented and preventable due to helmet use. The Blincoe report, on the other hand, presents costs realized due to various types of motor vehicle crashes *in addition* to costs prevented and preventable by motorcycle helmets.

An additional difference involves the crashes that are included in the cost estimation. Costs in this present research note are estimates of *reported* crashes only. FARS data, on which these estimates are based, is a census of fatal crashes which are required to be reported through law enforcement. This research note also uses the General Estimates System GES data to estimate the number of people injured at each MAIS level and is also reported data. This differs from the Blincoe report which bases estimates on *reported* data, but then adjusts them to account for unreported crashes. There are larger percentages of unreported injured at lower injury levels, so differences between all crashes and reported crashes are greater at lower injury levels.

The economic report presents estimates of all costs generated by crashes involving motorcycles, in addition to those specifically prevented and preventable by motorcycle helmets (Blincoe, Miller, Zaloshnja, & Lawrence, 2015, p. 187, Table 10-8). Finally, the costs reported in Blincoe (2015) are costs for the calendar year 2010. While those are the base costs used in this present research note, they have then been indexed for inflation to represent 2013 costs (to agree with the 2013 data used).

Results

In 2013, after adjusting for inflation, the *economic* cost to society for each motorcyclist fatality was $1.48 million, and the *comprehensive* cost of each fatality was $9.71 million. Nearly 85 percent of this *comprehensive* amount is attributable to lost quality of life. The loss of a life clearly has a tragic emotional impact on the family and friends of the deceased. The substantial economic loss, some immediate but much of it realized over upcoming years, is an additional burden they must bear. Helmets worn by motorcyclists saved an estimated 1,630 lives in 2013; an additional 715 lives could have been saved had all motorcyclists worn helmets. Forty-one percent of fatally injured motorcyclists in 2013 were unhelmeted. According to the National Occupant Protection Use Survey (NOPUS), the use of DOT-compliant helmets remained at 60 percent in 2013, unchanged from the previous year.

The overall *economic* cost savings in the United States due to helmet use was approximately $2.8 billion in 2013, and an additional $1.1 billion could have been saved if all motorcyclists had worn helmets. The overall *comprehensive cost* savings, including both economic costs and lost quality of life, was $17.3 billion, and an additional $7.2 billion in comprehensive costs could have been saved at 100-percent helmet use.

Table 3 presents the number of fatally injured motorcyclists as well as the percentage of them that wore helmets, by State, for the 2013 crash year. It is this number, fatally injured helmeted motorcyclists, on which the estimates of costs saved and numbers of motorcyclists prevented from being killed and injured are based. Also presented in the table are the estimated number of lives saved by helmets, and those that could have been saved at 100-percent helmet use; the economic costs saved and savable at 100-percent helmet use; and comprehensive costs (economic plus quality of life costs) saved and savable at 100-percent helmet use.

Texas had the highest number (491) of motorcyclist fatalities in 2013, while the District of Columba had the fewest, 3. Motorcycle helmet use rates in fatal crashes ranged from a high of 100 percent in the District of Columbia to a low of 7 percent in Maine. The number of lives saved by motorcycle helmets is a combination of both the number of riders, and the percentage of those wearing helmets. The largest number of motorcyclists' lives saved was in California (248), a State with 92-percent helmet use. Only 1 life was saved by helmets in Maine, with its low helmet use rate as well as having a relatively small number of motorcyclist fatalities.

Currently 19 States and the District of Columbia have universal helmet laws. Helmet use in fatal crashes in States with universal helmet laws averaged 91 percent in 2013, while in the remaining States helmet use averaged 38 percent. There were about 11 times as many unhelmeted motorcyclist fatalities in States without universal helmet laws (1,704 unhelmeted fatalities) as in States with universal helmet laws (150 unhelmeted fatalities) in 2013. States with universal helmet laws saved an average of 48 lives because more motorcyclists wore helmets, and could have saved an average of 3 more per State if all motorcyclists wore helmets. The States without universal helmet laws saved an average of 21 lives per State, and at 100-percent use could have saved, on average, an additional 21 per State. This highlights the effect of the higher use rates in States with universal helmet laws. Without such a law, only about half of those that could be saved, were saved, because of lack of helmet use. Looking at economic costs that were saved, and those that could have been saved, in States with universal helmet laws, 94 percent of the costs that *could* have been saved *were* saved by motorcyclists wearing helmets. In States without universal helmet laws, only 48 percent of possible costs that could have been saved actually were.

For further information on how the costs discussed in this Research Note were estimated, see Blincoe, Miller, Zaloshnja, and Lawrence (2015).

Table 3
Motorcyclist Fatalities, Helmet Use, Lives Saved, and Additional Savable at 100% Helmet Use, Costs Saved by, and Savable at 100% Helmet Use, 2013

State	Motorcyclists Helmets Used	Helmet Not Used	Unknown	Helmet Use Rate in Fatal Crashes (Known)	Total Fatals	Number of Fatals Prevented	Additional Fatals Preventable at 100% Use	*Economic Costs Saved	*Additional Econ Costs Savable at 100% Use	**Comprehensive (Econ + QoL) Costs Saved	**Add'l Comp Costs Savable at 100% Use
Alabama	78	1	1	99%	80	47	0	$68,906318	$526,439	$425,735,600	$3,387,347
Alaska	7	2	0	78%	9	4	1	$8,066,420	$1,350,093	$49,592,233	$8,678,427
Arizona	62	83	6	43%	151	38	32	$58,904,081	$46,220,396	$362,784,791	$297,273,448
Arkansas	19	39	3	33%	61	12	15	$16,990,268	$20,799,759	$104,966,844	$133,920,305
California	409	34	10	92%	453	248	13	$497,743,329	$22,734,044	$3,018,976,515	$146,232,159
Colorado	31	55	1	36%	87	19	21	$33,044,995	$35,946,901	$206,548,215	$231,675,693
Connecticut	22	21	10	51%	53	16	10	$36,603,224	$21,424,612	$229,299,479	$138,212,740
Delaware	13	7	0	65%	20	8	3	$12,941,090	$4,338,027	$80,743,785	$27,943,468
Dist. of Col.	3	0	0	100%	3	2	0	$5,107,923	$0	$31,971,215	$0
Florida	238	237	10	50%	485	144	90	$242,338,532	$143,538,390	$1,499,154,993	$924,689,050
Georgia	107	5	4	96%	116	66	2	$101,024,654	$2,778,741	$624,045,386	$17,889,073
Hawaii	10	19	0	34%	29	6	7	$10,899,551	$11,983,247	$66,551,785	$76,843,672
Idaho	12	12	1	50%	25	7	5	$10,582,766	$6,186,178	$65,187,135	$39,785,979
Illinois	35	113	4	24%	152	22	43	$41,882,998	$75,462,606	$256,318,102	$486,642,769
Indiana	18	82	14	18%	114	12	35	$17,847,712	$49,982,061	$111,203,434	$321,865,241
Iowa	10	31	0	24%	41	6	12	$9,936,524	$18,073,121	$62,286,778	$116,488,868
Kansas	15	18	2	45%	35	9	7	$15,334,545	$11,315,840	$95,901,536	$72,947,902
Kentucky	28	59	0	32%	87	17	22	$23,178,082	$29,953,854	$144,441,583	$192,850,149
Louisiana	66	18	2	79%	86	40	7	$63,554,709	$10,611,647	$396,843,574	$68,363,930
Maine	1	13	0	7%	14	1	5	$935,045	$7,454,288	$5,805,147	$47,929,912
Maryland	56	5	1	92%	62	34	2	$68,557,722	$3,707,736	$429,043,701	$23,899,006
Massachusetts	31	5	4	86%	40	20	2	$42,957,929	$4,257,668	$268,943,948	$27,468,615
Michigan	64	67	7	49%	138	40	26	$59,543,227	$38,066,351	$371,520,551	$245,165,569
Minnesota	16	34	11	32%	61	12	15	$20,912,890	$26,800,746	$130,840,613	$172,746,694
Mississippi	36	3	0	92%	39	22	1	$28,668,029	$1,424,736	$178,391,695	$9,162,155
Missouri	66	7	1	90%	74	40	3	$61,088,669	$3,946,713	$381,396,735	$25,422,018
Montana	12	22	1	35%	35	7	8	$11,028,170	$12,357,302	$68,644,353	479,526,426
Nebraska	12	1	1	92%	14	8	0	$12,380,000	$634,776	$77,454,608	$4,092,713
Nevada	48	7	2	87%	57	30	3	$45,923,563	$4,071,699	$285,995,111	$26,202,356
New Hampshire	7	17	0	29%	24	4	6	$7,571,303	$11,265,125	$47,227,598	$72,549,645
New Jersey	51	2	3	96%	56	32	1	$66,510,301	$1,599,197	$415,710,906	$10,306,311
New Mexico	13	20	8	39%	41	9	9	$13,450,994	$13,050,944	$83,603,448	$83,959,761
New York	147	16	7	90%	170	91	6	$186,784,286	$12,370,232	$1,162,145,805	$79,584,511
North Carolina	170	17	2	91%	189	102	6	$152,407,814	$9,326,474	$948,913,345	$60,024,622
North Dakota	5	3	1	63%	9	3	1	$5,563,042	$2,049,788	$34,758,099	$13,209,304
Ohio	43	87	2	33%	132	26	33	$39,093,462	$48,752,662	$243,480,189	$314,022,202
Oklahoma	15	77	0	16%	92	9	29	$13,666,107	$42,468,769	$85,413,945	$273,624,854
Oregon	32	2	0	94%	34	19	1	$29,930,651	$1,132,983	$185,899,850	$7,283,806
Pennsylvania	84	94	4	47%	182	52	35	$87,707,463	$58,978,022	$548,106,529	$379,978,099
Rhode Island	5	6	0	45%	11	3	2	$5,266,367	$3,858,641	$32,772,603	$24,828,132
South Carolina	43	106	0	29%	149	26	39	$36,172,401	$53,837,751	$224,923,619	$346,229,030
South Dakota	7	15	0	32%	22	4	6	$6,822,603	$8,820,479	$42,621,452	$56,816,345
Tennessee	126	11	0	92%	137	75	4	$109,657,800	$5,890,134	$684,264,243	$37,942,003
Texas	187	279	25	40%	491	118	109	$190,947,887	$174,623,436	$1,194,883,265	$1,125,864,593
Utah	12	19	0	39%	31	7	7	$9,860,720	$9,449,263	$61,365,411	$60,788,930
Vermont	5	2	0	71%	7	3	1	$5,153,366	$1,280,583	$32,107,614	$8,246,427
Virginia	76	3	0	96%	79	45	1	$83,044,487	$1,995,066	$520,508,635	$12,868,415
Washington	69	3	1	96%	73	42	1	$75,334,849	$1,992,955	$470,594,313	$12,839,304
West Virginia	16	8	0	67%	24	9	3	$12,999,083	$3,963,071	$80,816,479	$25,490,840
Wisconsin	21	62	2	25%	85	13	23	$20,499,487	$36,969,830	$127,891,452	$238,091,588
Wyoming	4	5	0	44%	8	2	2	$4,579,076	$3,606,525	$28,720,307	$23,284,142
Nation	**2,663**	**1,854**	**151**	**59%**	**4,668**	**1,630**	**715**	**$2,789,852,511**	**$1,123,228,901**	**$17,287,318,553**	**$7,235,138,549**
Puerto Rico	17	25	0	40%	42	10	9	$18,511,970	$16,844,793	$115,620,013	$108,555,188

*Economic Costs include lost produtivity, medical costs, legal and court costs, emergency service costs (EMS), insurance administration costs, congestion costs, property damage, and workplace losses.
**Comprehensive Costs include Economic Costs plus valuation for lost quality-of-life (QoL).
Cost data from Blincoe, Miller, Zaloshnja, & Lawrence, 2015.
Source: Fatality Analysis Reporting System 2013 Annual Report File (ARF); Bureau of Labor Statistics; Blincoe et al., 2015.
Motorcyclist Fatalities (Riders and Passengers) Helmet Use, FARS 2013, Lives and Costs Saved and Savable (Based on 2013 Cost)
Shaded States are those with laws requiring helmet use for all motorcyclists, at the time of publication.
State costs are adjusted for relative per-capita income; dollar amounts for the nation will not equal the sum of the States.

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This research note and other general information on highway traffic safety may be accessed by Internet users at: www-nrd.nhtsa.dot.gov/CATS/index.aspx

Appendix:
Calculating Lives and Costs Saved by Motorcycle Helmets

The process, formulae, and calculations used to estimate the number of lives saved and savable by motorcycle helmets, and the associated costs, were detailed in NCSA, 2011 (Appendix). This appendix uses the same process and formulas, with the following adjustments.

- Updated (2013) motorcycle fatal crash data
- Updated economic cost numbers with data from Blincoe, Miller, T. R., Zaloshnja, E., and Lawrence, 2015 (Revised)
- Updated inflation factor with information from the Bureau of Labor Statistics website
- Incidence of MAIS injury level now ascertained separately by helmet use
- Revised cost breakdown to use each MAIS level, rather than combining MAIS 2-5 into "serious" injury, as well as helmet use
- Added calculations and information on comprehensive cost numbers

The information needed to calculate these estimates is:

- For a given year, the number of motorcyclist fatalities, subdivided by helmet use and role (rider or passenger). This data would come from FARS. If you wish to look at States individually, you would also need this information subdivided by State.
- The number of motorcyclist fatalities for each of the past 5 years, subdivided by helmet use. This data is also from FARS.
- The estimated number of motorcyclists injured for each of the past 5 years, subdivided by helmet use. This data comes from NASS GES.
- The appropriate cost inflation factor, obtained from information on the Department of Labor's Bureau of Labor Statistics website (see below).

Motorcyclist Fatalities and Estimating the Number of Lives Saved

Data is obtained from FARS for the year of interest (Table A1) by helmet use and role.

Table A1
Motorcyclist Fatalities by Person Type and Helmet Use (Unknown Helmet Use Distributed, 2013)

	Operator	Passenger	All Motorcyclists
Helmeted	2,620	131	2,752
Unhelmeted	1,779	138	1,916
Total	**4,399**	**269**	**4,668**

Source: FARS 2013 ARF
Unknown helmet use has been distributed proportionally by role (operator or passenger).

The number of lives that were saved by motorcycle helmets is estimated using the number of helmeted fatally injured motorcyclists and the effectiveness estimate. For motorcycle operators, helmets have an estimated effectiveness of 0.37. First, the potential operator fatalities are calculated:

$$OperatorFatalities_{Potential} = \frac{OperatorFatalities_{\ Helmeted}}{(1 - 0.37)}$$

Using the number of helmeted operator fatalities above (2,620), this is:

$$OperatorFatalities_{Potential} = \frac{2{,}620}{(1 - 0.37)} = 4{,}159$$

The number of potential fatalities less the number actual fatalities gives the number of lives saved by helmets. In this case, 4,159 – 2,620 = 1,539

For motorcycle passengers, helmets have an effectiveness of 41 percent. So, in 2013, the calculations for the number of motorcycle passenger lives saved are estimated by:

$$PassengerFatalities_{Potential} = \frac{131}{(1 - 0.41)}\ 222$$

The number of motorcycle passenger fatalities prevented is 222 – 131 = 91

So the total number of lives saved by motorcycle helmets nationwide in 2013 is 1,539 + 91 = 1,630

For ease of presentation, values are rounded at each step calculated in examples in this Appendix. Therefore small differences may occur between values calculated here and those presented elsewhere, or when adding individual States compared to the national total.

Estimating additional preventable fatalities at 100-percent helmet use

The additional lives that could be saved if all motorcyclists had worn helmets are calculated using the number of unhelmeted fatally injured motorcyclists and the effectiveness estimate.

$$MotorcyclistFatalities_{Unhelmeted} \times Effectiveness_{role}$$

For operator fatalities, using the number of unhelmeted operator fatalities from Table A1, this is 1,779 × 0.37 = 658

Had all of these 1,779 riders that died in crashes been wearing helmets, 658 (37 percent) of them would have survived.

The number of additional lives that could have been saved if all passengers had worn helmets is:

$$138 \times 0.41 = 57$$

Therefore, a total of 715 additional lives (658 operators and 57 passengers) could have been saved had all motorcyclists worn helmets.

Estimating the total number of Motorcyclists Injured

The method used to estimate costs saved by motorcycle helmets requires information on injury severity. NCSA maintains a number of crash data files. The Fatality Analysis Reporting System (FARS) is a census of fatal crashes in the United States. The General Estimates System (GES), part of the National Automotive Sampling System (NASS), is a sample of reported traffic crashes to which weights are applied in order to obtain national estimates. Data from both of these systems are used together to estimate the number of motorcyclists by role (passenger or operator), helmet use, and injury severity for Maximum Abbreviated Injury Scale (MAIS) levels 1 through 5. MAIS 6 is a fatal injury, and FARS data is used in that case. Since the GES data is not collected in every state, these calculations allows for lives and cost saved estimates for each State, rather than only on a nationwide basis.

The initial step is to determine the total number of motorcyclist fatalities (from FARS) and the estimated number injured (from GES), separately by helmet use, using the most recent five years of data. Fatality counts in Table A2 exclude those with unknown helmet use, since it is the proportion required here, not a numerical count.

The ratio of injured motorcyclists to fatalities, by helmet use, is calculated for each year, and then the average of the five injury-to-fatality ratios is calculated. Using 5 years, rather than only the most recent, gives a better estimate as it controls for the year-to-year variability inherent in any sampling system. The numbers presented in Table A3 are rounded, while the actual calculations are based on unrounded numbers.

For helmeted motorcyclists, this is:

$$\frac{23.04 + 20.93 + 19.98 + 20.75 + 20.25}{5} = 20.99$$

For unhelmeted motorcycles, this is:

$$\frac{16.23 + 14.57 + 14.12 + 14.38 + 14.82}{5} = 14.82$$

These ratios give us the number of injured motorcyclists for every motorcyclist fatality. So, there are about 21 injured, helmeted motorcyclists for each helmeted motorcyclist that dies in a traffic crash. The appropriate ratio is then used to estimate the number of injured motorcyclists, by helmet use as well as role

Table A2
Total Motorcyclist Fatalities and Injured, 2009–2013

Year	Fatalities		Injured		Injury to Fatality Ratio	
	Helmeted	Unhelmeted	Helmeted	Unhelmeted	Helmeted	Unhelmeted
2009	2,506	1,963	57,748	31,860	23.04	16.23
2010	2,614	1,904	54,708	27,740	20.93	14.57
2011	2,737	1,893	54,669	26,730	19.98	14.12
2012	2,813	2,039	58,365	29,324	20.75	14.38
2013	2,663	1,854	53,934	27,482	20.25	14.82
Total	—	—	—	—	**20.99**	**14.82**

Source: FARS 2009–2012 Final File, 2013 ARF and GES 2009–2013 (rider or passenger). Multiplying each of the helmeted values in Table A1 by 20.99, and each unhelmeted value by 14.82 results in:

Table A3
Estimates of Motorcyclists Injured, by Person Type and Helmet Use, 2013

	Operator	Passenger	All Motorcyclists
Helmeted	55,001	2,757	57,758
Unhelmeted	26,368	2,040	28,408
Total	**81,369**	**4,798**	**86,166**

Estimating the number of injured motorcyclists at each injury level

Previously, the process used to estimate the number of injured motorcyclists allowed estimates separating injured into two groups, minor (MAIS 1) and seriously (MAIS 2-5) injured motorcyclists. Using relative incidence of injury level in reported crashes, provided in Blincoe, Miller, Zaloshnja, and Lawrence (2015), estimation of the number of injured motorcyclists at each individual MAIS level is now possible. The relative incidence of injury at each MAIS level is shown in Table A4 (which is the same as Table 1, and repeated here for convenience).

Table A4
Relative Injury Incidence in Reported Crashes, by Helmet Use

MAIS Level	Helmeted	Unhelmeted
1	0.64	0.62
2	0.22	0.23
3	0.12	0.14
4	0.01	0.01
5	0.01	0.01

Source: The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised) [Note: Shown are rounded values, obtained from the incidence of motorcyclists at each injury level in Tables 10-4 and 10-5.]

Using this incidence of motorcyclists by injury level and helmet use status, 64 percent of injured helmeted motorcyclists are estimated to be injured at MAIS level 1, 22 percent at MAIS level 2, twelve percent at MAIS 3, and one percent at each MAIS levels 4 and 5. For example, if there were 100 injured helmeted motorcyclists in a given state in one year, the estimated number of those with MAIS 1 injuries would be 64, with 22 MAIS 2, 12 MAIS 3, and 1 each at MAIS 4 and MAIS 5. For injured motorcyclists that were unhelmeted, similar calculations would be made using the second column in Table A4.

So, given 55,001 helmeted operators injured (from Table A3):

Number of MAIS 1 helmeted motorcycle operators:

$$0.64 \times 55{,}001 = 35{,}201$$

Number of MAIS 2 helmeted motorcycle operators:

$$0.22 \times 55{,}001 = 12{,}100$$

Number of MAIS 3 helmeted motorcycle operators:

$$0.12 \times 55{,}001 = 6{,}600$$

Number of MAIS 4 helmeted motorcycle operators:

$$0.01 \times 55{,}001 = 550$$

Number of MAIS 5 helmeted motorcycle operators:

$$0.01 \times 55{,}001 = 550$$

Calculations would be similar for unhelmeted motorcycle operators, and helmeted and unhelmeted motorcycle passengers. (Note that for the results in these calculations, the rounded incidence values presented above in Table A4 were used. In calculations for estimates of annual lives and costs saved in motorcycle crashes, the unrounded ratios using incidence values from Table 10-2 of Blincoe et al. [2015] are used.) Table A5 presents the estimates for motorcyclist by MAIS level, role, and helmet status.

Table A5
Estimates of Motorcyclists Injured, by Person Type, Helmet Use, and MAIS level, 2013

	Operator		Passenger	
	Helmeted	Unhelmeted	Helmeted	Unhelmeted
MAIS 1	35,201	16,348	1,764	1,265
MAIS 2	12,100	6,065	607	469
MAIS 3	6,600	3,692	331	286
MAIS 4	550	264	28	20
MAIS 5	550	264	28	20

Estimating the number of motorcyclists prevented from being injured because of motorcycle helmets, at each injury level

The number of motorcyclists whose injuries were prevented by helmets is estimated using the same process that was used for estimating the number of lives saved (above), but at each MAIS level. Recall that the effectiveness estimates for saving lives were 37 percent for operators and 41 percent for passengers. The effectiveness estimate for preventing a motorcyclist from receiving a minor injury is 8 percent and for preventing a seriously injured motorcyclist (MAIS 2–5), 13 percent. The estimate for the effectiveness of motorcycle helmets in preventing *injuries* is the same for both operators and passengers. Note that distributing injured motorcyclists by each MAIS level will not affect the estimated *total number* of motorcyclists prevented from being injured, since the effectiveness estimate is the same for all MAIS levels 2 through 5. However, the *cost* estimates differ by MAIS level, so the amount of money saved (and savable at 100% helmet use) is better estimated by separating those injured by MAIS level.

To estimate the number of motorcyclists whose helmets prevented them from receiving a serious (MAIS level 2 through 5) injury, the number of helmeted motorcyclists is used. First the number of potentially seriously injured is estimated:

$$\textit{Seriously Injured}_{Potential} = \frac{\textit{Seriously Injured}_{\;Helmeted}}{(1 - 0.13)}$$

Using the estimate of helmeted, seriously injured motorcyclists above, the sum of both operators and passengers at MAIS levels 2 through 5 (20,793[3]), this is:

$$\textit{Seriously Injured}_{Potential} = \frac{20{,}793}{(1 - 0.13)} = 23{,}900$$

The number of potential seriously injured, less the number actual seriously injured, gives the number of seriously injured prevented by helmets. In this case, 23,900 – 20,793 = 3,107. Again, these calculations are being shown using rounded numbers, whereas during the actual calculations rounding would not occur until presenting the final value.

The number of potential minor injured (MAIS 1) motorcyclists is:

$$\textit{Minor Injured}_{Potential} = \frac{\textit{Minor Injured}_{\;Helmeted}}{(1 - 0.08)}$$

Using the estimate of helmeted minor injured motorcyclists above (35,201 + 1,764 = 36,965), this is:

$$\textit{Minor Injured}_{Potential} = \frac{36{,}965}{(1 - 0.08)} = 40{,}179$$

The number of potential minor injured, less the number actual minor injured, gives the number of minor injured prevented by helmets. In this case, 40,179 – 36,965 = 3,214.

Estimating the number of additional motorcyclists prevented from being injured at 100-percent Helmet Use, at each injury level

The number of motorcyclists whose injuries could have been prevented if all had worn helmets is estimated using the same method as previously shown for motorcyclist fatalities. Again, there are not different injury effectiveness estimates for riders and passengers. There are, however, different effectiveness estimates for the two levels of injury. The number of injured motorcyclists that could have been prevented is calculated as:

$$\textit{MotorcyclistsInjured(Injurylevel)}_{Unhelmeted} \times \textit{Effectiveness}_{InjuryLevel}$$

From Table A5, there were 11,080 unhelmeted motorcyclists who were seriously injured. The estimate of the number of additional motorcyclists whose serious injuries could have been prevented is:

$$11{,}080 \times 0.13 = 1{,}440$$

And for those with minor injuries, this is:

$$17{,}613 \times 0.08 = 1{,}409$$

Economic Impact

Cost savings are calculated by multiplying the number of motorcyclists who were prevented from being injured or killed by the associated economic cost. The cost bases, as well as detailed information on how they were estimated, come from *The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised).* Costs associated with motorcycle injuries are different from those for general (all vehicle) crashes, because the injuries motorcyclists suffer differ from the general injuries at each MAIS level. See chapter 10 of Blincoe, Miller, Zaloshnja, and Lawrence (2015) for the reasoning on costs associated with motorcyclist MAIS level injuries.

The costs in Blincoe, Miller, Zaloshnja, and Lawrence (2015) use 2010 crash data, and are expressed in 2010 dollars. Costs in the present research note use 2013 crash data, and adjust for inflation, from 2010 dollars to 2013 dollars, in order to agree with the 2013 FARS data.

The required inflation factor is obtained using data from the Department of Labor's Bureau of Labor Statistics, at its website at http://data.bls.gov/cgi-bin/surveymost?cu.

To obtain the needed values, place a check in the first item's box ("U.S. All items, 1982–84=100 – CUUR0000SA0") then scroll to the bottom and click "Retrieve data." If necessary, you can modify the range of years in the "Change Output Options" section at the top of the screen. If the table presented does not have a column labeled "Annual," check the box for "include annual averages," and click "Go."

For the inflation factor, divide the value for "Annual" for the relevant data year (2013) by that of the base year index (2010 for our calculations, since the known value is the cost per fatality and injured in year 2010 dollars). For example, to convert 2010 dollars to 2013, the values are 232.957/218.056 = 1.068. The cost at each MAIS level or fatality is multiplied by the inflation factor to get the current-year cost per fatality or injury. The 2013 economic cost per fatality, then, is inflated from year 2010 dollars to year 2013 dollars by:

$$\$1{,}381{,}645 \times 1.068 = \$1{,}475{,}597$$

Table A6 presents the dollar values associated with each fatality and MAIS level, for both economic costs and comprehensive costs, used in the present research note. Note that, for simplicity and clarity, the values in Table A6 use the rounded value of 1.068 as the inflation multiplier. When calculating estimates, the unrounded 218.056/232.957 would be used.

State and/or national cost savings are then estimated by multiplying the number of motorcyclists who were prevented from being killed or injured separately by each MAIS level (including those fatally injured) by the corresponding economic and comprehensive costs, and summing all injury levels. For example,

[3] This is obtained by adding together all seriously injured helmeted motorcyclists. From Table A5, these values are 12,100 + 6,600 + 550 + 550 + 607 + 331+ 28 + 28 = 20,793.

Table A6

Economic and Comprehensive Unit Costs per Injured Motorcyclist, by Injury Level and Helmet Use, 2010 and 2013

Helmet Use	Injury Level	2010 Costs		2013 Costs	
		Unit Economic Cost	Unit Comprehensive Cost*	Unit Economic Cost	Unit Comprehensive Cost*
Helmeted	MAIS 1	$18,079	$30,915	$19,308	$33,017
	MAIS 2	$48,186	$220,580	$51,463	$235,579
	MAIS 3	$184,941	$759,107	$197,517	$810,726
	MAIS 4	$328,872	$1,701,424	$351,235	$1,817,121
	MAIS 5	$1,190,011	$4,909,241	$1,270,932	$5,243,069
	Fatal	**$1,381,645**	**$9,090,622**	**$1,475,597**	**$9,708,784**
Unhelmeted	MAIS 1	$18,941	$32,926	$20,229	$35,165
	MAIS 2	$49,258	$227,273	$52,608	$242,728
	MAIS 3	$184,639	$763,673	$197,194	$815,603
	MAIS 4	$352,587	$1,852,270	$376,563	$1,978,224
	MAIS 5	$1,617,283	$7,564,608	$1,727,258	$8,079,001
	Fatal	**$1,381,645**	**$9,090,622**	**$1,475,597**	**$9,708,784**

Source: *The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised)*, Tables 10-6 and 10-7, adjusted for inflation using data from Department of Labor's Bureau of Labor Statistics to estimate 2013 costs (see text).
*Comprehensive costs consist of Economic and Lost Quality-of-Life Costs.

earlier it was estimated that nationwide, 1,630 lives were saved by motorcycle helmets in 2013. This resulted in an economic cost savings (in 2013 dollars) of:

$$\$1,475,597 \times 1,630 = \$2,405,223,110$$

and a comprehensive cost savings of:

$$\$9,708,784 \times 1,630 = \$15,825,317,920$$

that can be attributed to helmets having prevented fatalities. The economic and comprehensive cost savings at each MAIS level for injured motorcyclists would be calculated in the same way, using the number of motorcyclists prevented from being injured and the corresponding dollar amounts for helmeted injured motorcyclists. Finally, all injury level and fatality costs are summed to estimate a total cost savings from the use of motorcycle helmets.

To calculate the economic and comprehensive costs that could have been saved had all motorcyclists been wearing helmets, the cost savings for each fatality and injury level is multiplied by the number of lives that could have been saved, or the number of motorcyclist who received injured that could have been prevented.

The economic cost savings for fatalities that could have been prevented by 100-percent helmet use is:

$$\$1,475,597 \times 715 = \$1,055,051,855$$

The comprehensive cost saving for fatalities that could have been prevented by 100-percent helmet use is:

$$\$9,708,784 \times 715 = \$6,941,780,560$$

The complete additional cost savings for fatalities and injured motorcyclists preventable at 100-percent helmet use (for the nation, a State, or other grouping) would be calculated by summing the dollar amounts for fatalities and each injury level.

Again, because of rounding used for ease of presentation, the additional dollar amount that could have been saved had all motorcyclists worn helmets differs from the amount presented in Table 3 as well as other published values.

Numbers in the above examples are national totals. For the data in Table 3 for individual States, the number of fatalities by helmet use for each State is used. The dollar amount is adjusted for each state using a ratio of the per-capita personal income in the specific state to the national average per-capita personal income. The rationale for this method is explained in *A Model for Estimating the Economic Savings from Increased Motorcycle Helmet Use*. Depending on the number of motorcyclist fatalities in each State, summing the State costs may differ from the cost estimate based on the national total. The national totals presented in Table 3 are calculated directly from the national counts and cost estimates, and are calculated without intermediate rounding.