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Lower-Extremity Injuries in Motorcycle Crashes

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16. Abstract <p>This study aims to define the characteristics of lower-extremity injuries among motorcyclists involved in traffic crashes. The results of this study provide information on the cost of different types of lower-extremity injuries and long-term disabilities that might result from these types of injuries.</p> <p>Methods: Crash information was obtained from examination of the National Automotive Sampling System/General Estimate System for the years 1997 to 2006. The Fatality Analysis Reporting System from 1997 through 2006 was used to develop a trend in motorcycle-related fatalities. The National Trauma Data Bank-National Sample Program (NTDB-NSP) from 2003 through 2005 was used to identify injury distribution by body region and to examine the frequency and type of lower-extremity injuries, hospital charges, and discharge disposition for motorcyclists who sustained lower-extremity injuries.</p> <p>Results: The number of motorcycle crashes has increased in the period from 1997 to 2006. There is an estimated 61 percent increase in the number of motorcyclists in traffic crashes in 2006 compared to 1997. The fatalities have increased from 2,028 in 1997 to 4,654 in 2006, accounting for a 129-percent increase. Most incapacitating and fatal injuries were sustained when the Initial Point of Impact was the front of the motorcycle. The analysis of the NTDB-NSP showed that lower-extremity injuries were the most common injuries sustained in motorcycle crashes, followed by upper-extremity and head injuries. Lower-extremity injuries are more frequent in motorcycle crashes; however, head, chest and abdominal injuries tend to be more severe. Motorcyclists involved in crashes sustain more leg injuries with bone fractures being the most common type of injuries when compared to soft tissue injuries. Overall, an estimated 81 percent of motorcyclists with isolated lower-extremity injuries were discharged home after acute hospital care. The discharge disposition has varied according to the number of lower-extremity injuries and their combination with other injuries. Hospital charges varied according to the number of lower-extremity injuries sustained by motorcyclists. Motorcyclists who sustained single-isolated lower-extremity injuries had an estimated median of \$21,000 on hospital charges per patient. The median charges increased to an estimated \$39,000 per patients with multiple lower-extremity injuries and was the highest for motorcyclists who sustained lower-extremity in combination with other injuries, at \$56,000 per patient. An estimated 59 percent of the injured motorcyclists who sustained AIS 2+ injuries were covered by commercial health insurance or paid for by automobile insurance. An estimated 20 percent of the injured motorcyclists did not have any source of health insurance and were coded as self-pay. Medicaid and Medicare combined paid for an estimated 7 percent of the injured motorcyclists included in the analysis.</p>					
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Executive Summary

Objective: This study aims to understand the specific characteristics of lower-extremity injuries among motorcyclists within the context of overall trends in motorcycle injuries and fatalities. The results of this study provide information on the cost of different types of lower-extremity injuries and long-term disabilities that might result from these injuries.

Methods: Crash information was obtained from examination of the National Automotive Sampling System/General Estimate System (NASS/GES) for the years 1997 to 2006. The Fatality Analysis Reporting System (FARS) from 1997 through 2006 was used to establish a trend in motorcycle-related fatalities. Due to lack of medical information in NHTSA-acquired crash data such as NASS/GES and FARS, the National Trauma Data Bank-National Sample Program (NTDB-NSP) from 2003 through 2005 was used to identify the injury distribution by body region for injured motorcyclists treated in level I or II trauma centers and to examine the frequency and type of lower-extremity injuries, hospital charges, and discharge disposition for motorcyclists who sustained lower-extremity injuries.

Results: The number of State-reported motorcycle crashes has increased in the period from 1997 to 2006. There is an estimated 61 percent increase in the number of motorcyclists in traffic crashes in 2006 compared to 1997. The fatalities have increased from 2,028 in 1997 to 4,654 in 2006, accounting for a 129 percent increase. Most incapacitating and fatal injuries were sustained when the initial point of impact (IPI) was the front of the motorcycle. The analysis of the NTDB-NSP showed that lower-extremity injuries were the most common injuries sustained by motorcyclists treated in level I and II trauma centers, followed by upper-extremity and head injuries. While lower-extremity injuries were more frequent, head, chest, and abdominal injuries tended to be more severe. An estimated 97 percent of AIS 2 or higher (2+) lower-extremity injuries were of AIS 2 or 3. Injured motorcyclists sustain more leg injuries than any other type of lower-extremity injury, with bone fractures being more common than soft-tissue injuries.

Overall, an estimated 81 percent of the patients with isolated lower-extremity injuries were discharged home after acute hospital care. The discharge disposition varied according to the number of lower-extremity injuries and their combination with other injuries. Only an estimated 45 percent of motorcyclists who sustained a combination of AIS 2+ lower-extremity as well as injuries to other body regions were discharged home after acute hospital care.

Hospital charges varied according to the number of lower-extremity injuries sustained by motorcyclists. Motorcyclists who sustained single-isolated lower-extremity injuries had an estimated median of \$20,745 on hospital charges per patient. The estimated median charges increased to \$38,608 per patient with multiple lower-extremity injuries and was the highest for motorcyclists who sustained lower-extremity in combination with other injuries, at an estimated \$56,288 per patient.

An estimated 59 percent of the injured motorcyclists who sustained AIS 2+ injuries were covered by a commercial health insurance or paid for by automobile insurance. An estimated 20 percent of the injured motorcyclists did not have any source of health insurance and were coded as self-pay. Medicaid and Medicare combined paid for an estimated 7 percent of the injured motorcyclists included in the analysis.

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INTRODUCTION

Motorcycle crashes result in significant numbers of mortality and morbidity in traffic crashes in the United States. Over the years, there have been multiple safety campaigns targeted to motorcyclists. These campaigns included promotion of proper use of safety helmets and to encourage motorcyclists to be adequately illuminated, especially at night.⁵

Motorcyclists represent a particularly vulnerable group of road users. Due to their relatively small size compared to other vehicles, motorcycles are often missed, not noticed, or fall in the blind spot of other drivers.⁸ Relative to car crashes, motorcycle crashes have received relatively less attention by the research community despite the high mortality rates. This report provides trends in motorcycle crashes as well as motorcyclists' morbidity and mortality in the period from 1997 to 2006. The report also provides detailed information on lower-extremity injuries among motorcyclists treated in level I or II trauma centers such as frequency of different types of lower-extremity injuries, hospital charges, discharge disposition and payors for such injuries.

METHODS

This study provides a statistical analysis of three different databases:

(1) The NASS/GES⁷ is a complex probability sample of all State-reported traffic crashes that occurred in a given year. The NASS/GES data is weighted to produce national estimates. The weights result from the probabilities associated with each stage of selection, reflecting that crash's probability of selection. NASS/GES reports injuries with different severity. The injuries are reported based on the police reports using the "KABCO" scale: fatal injury (K), incapacitating injury (A), non-incapacitating injury (B), possible injury (C), or no injury (O), plus injured- severity unknown, died prior to crash, or unknown if injured.

(2) The Fatality Analysis Reporting System (FARS)⁶ is on a census of fatal traffic crashes in the 50 States, the District of Columbia, and Puerto Rico. FARS includes all crashes that involve a motor vehicle traveling on a trafficway open to the public and result in the death of a person (occupant of a vehicle or a nonoccupant) within 30 days of the crash. FARS also reports injuries with different severity in the same manner as NASS/GES with the requirement that the crash involve at least one fatality.

(3) The National Trauma Data Bank-National Sample Program (NTDB-NSP) is a unique and powerful database that includes clinical and resource information for a nationally representative sample of trauma incidents. NTDB-NSP is a stratified sample based in large part on existing NTDB data, which is the largest aggregation of trauma registry data. Researchers can use the NTDB-NSP to produce national estimates of trauma care. For privacy reasons, the NTDB-NSP excludes data elements that could directly or indirectly identify individuals or individual trauma centers.

To establish the NTDB-NSP, a stratified sample design was used, and 100 sample hospitals of level I and level II were included. Stratification was based on U.S. Census region (four regions), level of trauma care designation (two categories), and NTDB reporting status (two categories). Thus, there were 16 total strata: 8 NTDB strata and 8 non-NTDB strata. Of the 100 sample

hospitals, 90 were allocated to the known NTDB-contributing hospitals and 10 to non-NTDB hospitals. The sample size of 100 hospitals was chosen on the basis of recent NTDB data that suggested that a sample of 100 hospitals would provide estimates having sufficient precision for most analyses at the national level.¹

In the NTDB-NSP, motorcyclists involved in motorcycle crashes were identified by using the International Classification of Diseases, External Cause of Injury, Ninth Revision (ICD-9 E-Codes) between 810.2 and 819.3. Information on external causes of injury is coded and entered into the State's electronic hospital discharge data system (HDDS) or hospital emergency department data system (HEDDS).⁹ Although the NTDB-NSP provides detailed medical and demographic information about these injured motorcyclists, it lacks the information on crash characteristics such as crash direction, crash severity, and manner of collision.

When analyzing NTDB-NSP, only patients 15 and older with Abbreviated Injury Scale² (AIS) severity of 2 (moderate) or higher injuries were included. Among motorcyclists who sustained AIS 2+ injuries, the injury or injuries with highest AIS for each body region were selected for analysis. For example a person with head injuries of AIS 2, 3, and 4 and lower-extremity injuries with AIS 2 and 3, both head injury with AIS 4 and lower-extremity injury with AIS 3 were included in the analysis. Injuries sustained by motorcyclists included in the analysis were grouped as single-isolated lower-extremity (one 2+ lower-extremity injury and no other 2+ injuries), multiple lower-extremity (two or more 2+ lower-extremity injuries and no other 2+ injuries), lower-extremity and other injuries (one or more 2+ lower-extremity and one or more other 2+ injuries), and non-lower-extremity injuries (no 2+ lower-extremity injuries and one or more other 2+ injuries).

To identify the frequency of different lower-extremity injuries, lower-extremity was grouped into eight regions: foot, ankle, leg, knee, thigh, hip, pelvis and "others" regions. When analyzing type of lower-extremity injuries, all injuries sustained by motorcyclists were included. For example if a motorcyclist sustained two tibia fractures, both injuries were included in the analysis.

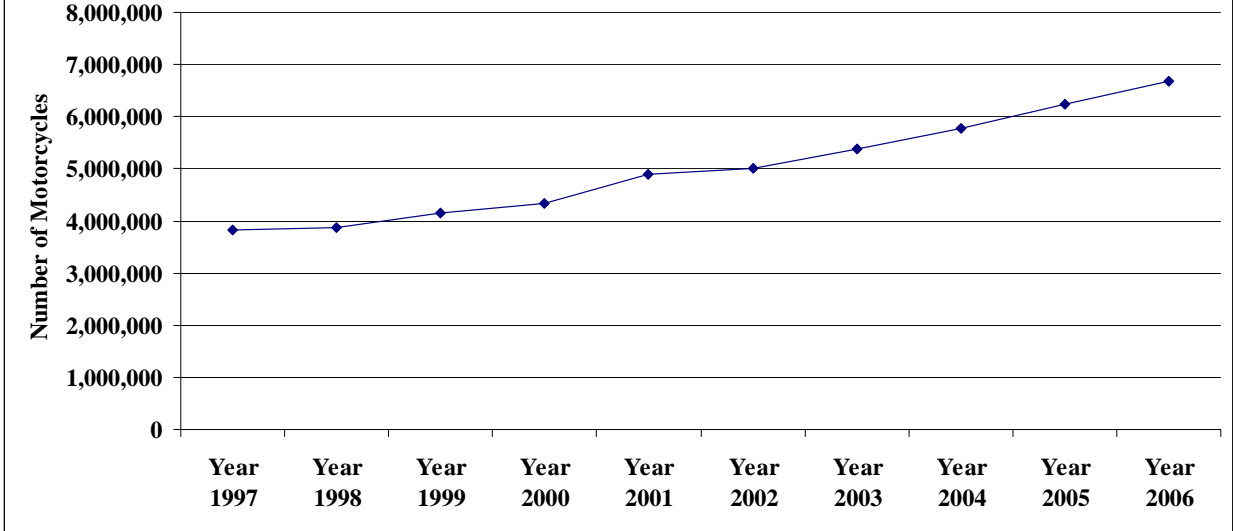
Hospital charges and discharge disposition of motorcyclists injured in crashes were calculated and compared across the four groups (single-isolated lower-extremity, multiple lower extremities, lower-extremity and other injuries, non-lower-extremity injuries).

RESULTS

Trends in Motorcycle Registration and Motorcyclists Involved in Traffic Crashes

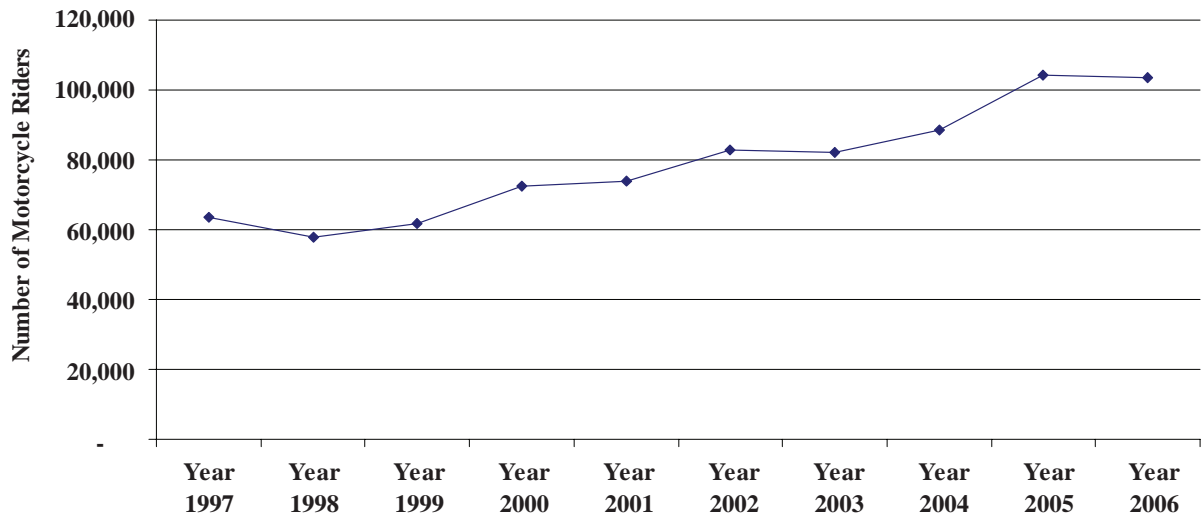
According to the Federal Highway Administration³ (FHWA), the number of registered motorcycles has increased from approximately 4 million motorcycles in 1997 to about 7 million in 2006 (Figure 1).

Figure 1: Registered Motorcycles in the United States 1997-2006
 Source: The Federal Highway Administration's (FHWA)



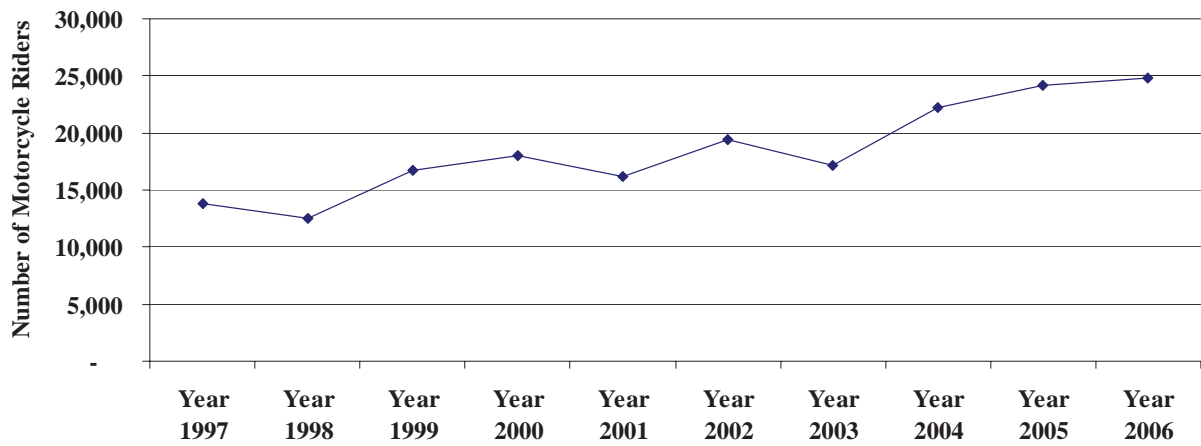
Analysis of NASS/GES data from 1997 to 2006 showed an overall increase in the estimated number of motorcyclists involved in traffic crashes. The total number of motorcyclists involved in crashes in 1997 was an estimated 64,000; the number increased to an estimated 103,000 in 2006 (Figure 2). This accounts for an approximately 61-percent increase in the number of motorcyclists in traffic crashes. Trend analysis of both NASS/GES and FARS showed an increase in both motorcyclists with incapacitating injuries and mortalities during the 10 years of data analysis. The fatalities have increased from 2,028 in 1997 to 4,654 in 2006, accounting for a 129-percent increase. The estimated number of motorcyclists who sustained incapacitating injuries has increased from 14,000 in 1997 to 25,000 in 2006, accounting for an almost 80-percent increase (Figures 3 and 4).

Figure 2: Trend in Estimated Number of Motorcyclists Involved in Traffic Crashes



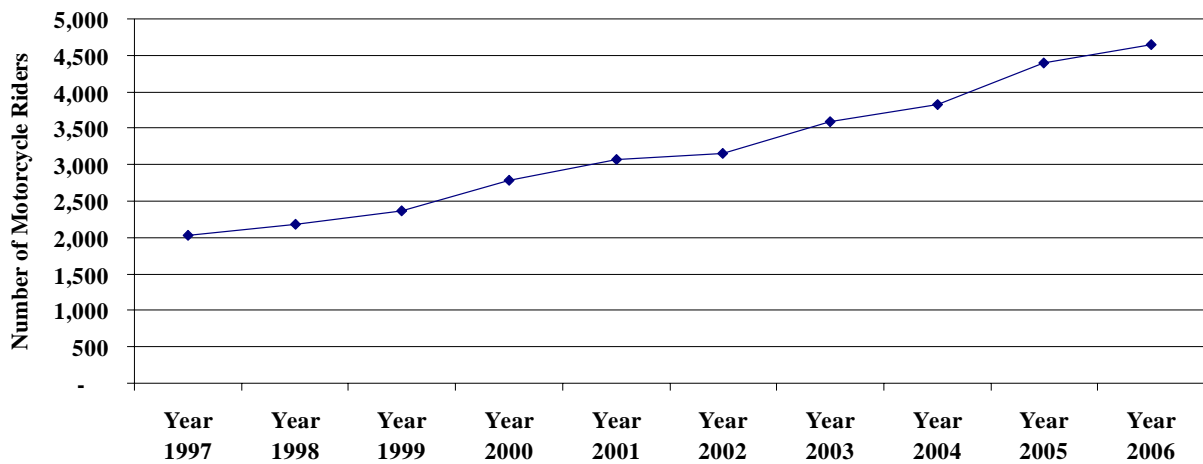
Source: NASS/GES 1997-2006

Figure 3: Trend in Estimated Number of Motorcyclists Who Sustained Incapacitating Injuries In Traffic Crashes



Source: NASS/GES 1997-2006

Figure 4: Trend in Number of Motorcyclists Fatalities in Traffic Crashes

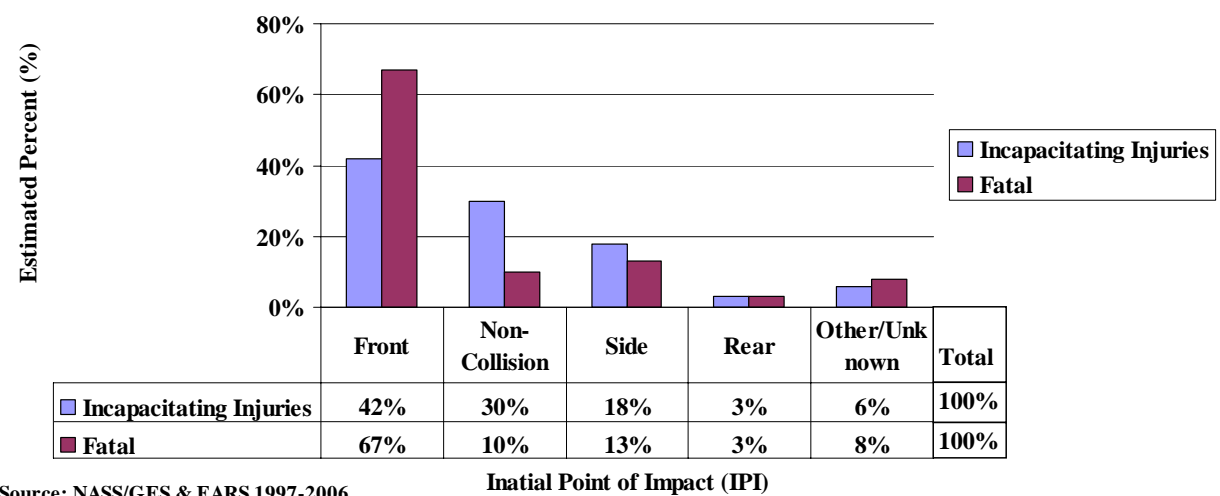


Source: FARS 1997-2006

Crash Characteristics of Motorcyclists With Fatal or Incapacitating Injuries

Analysis of both FARS and NASS/GES on the initial point of impact (IPI) showed that in 67 percent of the motorcycle fatalities the IPI was the front of the motorcycle. Another 10 percent were coded as noncollision, such as laying the motorcycle down on its side. An estimate of 42 percent of the incapacitating motorcycle injuries were sustained when the IPI was the front, followed by noncollisions accounting for an estimate of 30 percent of those with incapacitating injuries (Figure 5).

Figure 5: Estimated Percent of Initial Point of Impact Associated With Incapacitating & Fatal Injuries in Motorcycle Crashes



Source: NASS/GES & FARS 1997-2006

Impact of Lower-Extremity Injuries in Trauma Center Patients

The National Trauma Data Bank- National Sample Program (NTDB-NSP) was used to assess the impact of lower-extremity injuries in motorcycle crashes among motorcyclists 15 and older. An estimated total of about 47,000 injured motorcyclists were treated in level I or II trauma centers during the period from 2003 to 2005 with an estimated annual average of 16,000. Of the estimated 47,000 injured motorcyclists, an estimate of about 41,000 (87%) had a minimum of one AIS 2+ injury. Of the 41,000 motorcyclists who suffered AIS 2+ injuries, an estimate of about 19,000 sustained 36,000 different lower-extremity injuries for an average of a little less than two lower-extremity injuries per person. An estimated 10 percent of the motorcyclists with AIS 2+ injuries had an isolated-single lower-extremity injury, 9 percent had multiple lower-extremity injuries, and 28 percent had lower-extremity injuries combined with injuries to other body regions. An estimated 53 percent of the motorcyclists included in the analysis did not have any lower-extremity injuries (Table 1 & Figure 6).

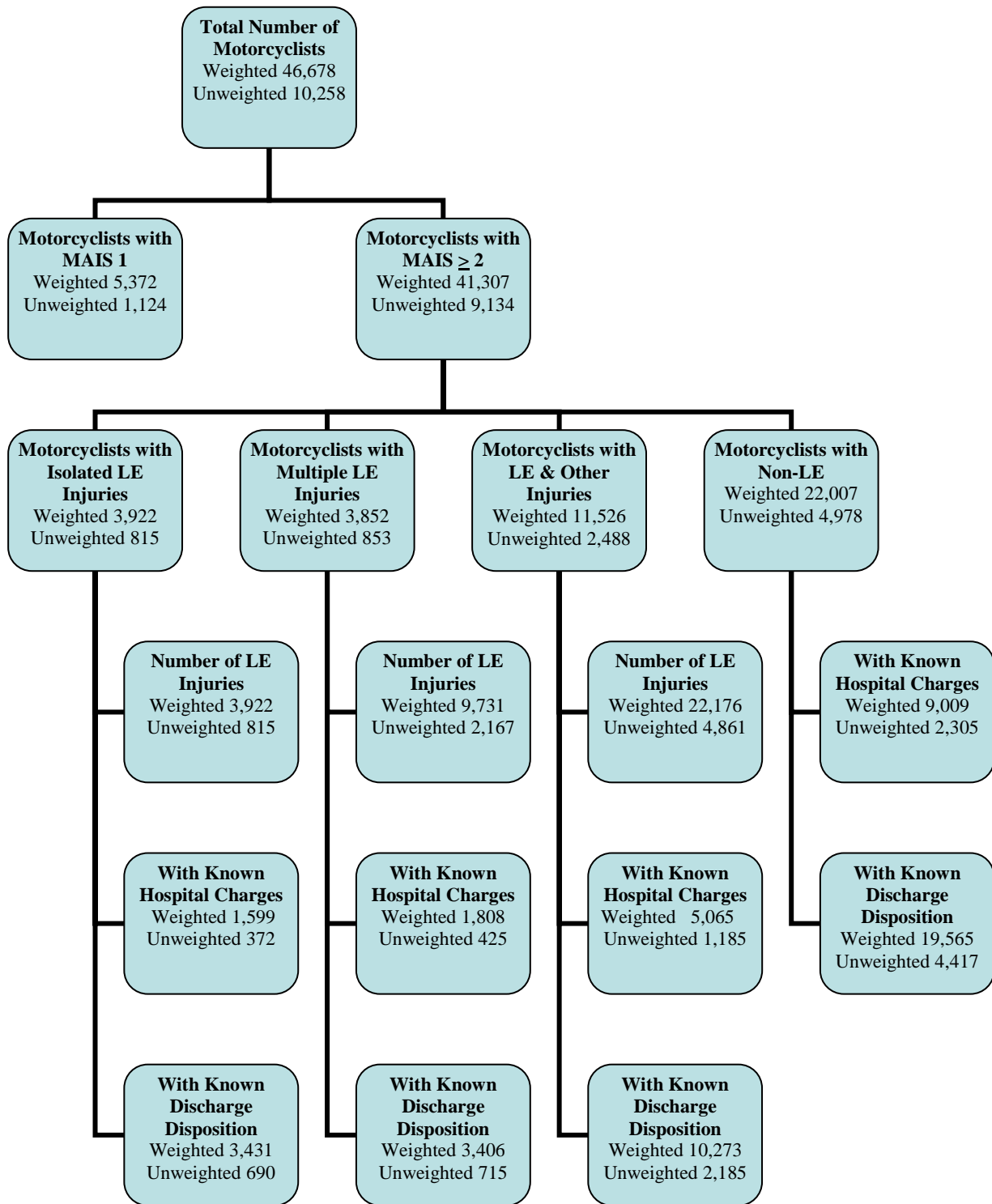
Table 1: Weighted and Unweighted Number of Motorcyclists With AIS 2+ Lower-Extremity Injuries

Injury Group	Weighted Frequency	Weighted Percent	Unweighted Frequency	Unweighted Percent
Single-Isolated Lower-Extremity	3,922	10%	815	9%
Multiple Lower-Extremity	3,852	9%	853	9%
Lower-Extremity and Other Injuries	11,526	28%	2488	27%
Non-Lower-Extremity	22,007	53%	4,978	55%
Total	41,307	100%	9,134	100%

Source: NTDB-NSP 2003-2005

The flowchart shown in Figure 6 provides the distribution of motorcyclists and injuries used in the analysis of NTDB-NSP throughout the study.

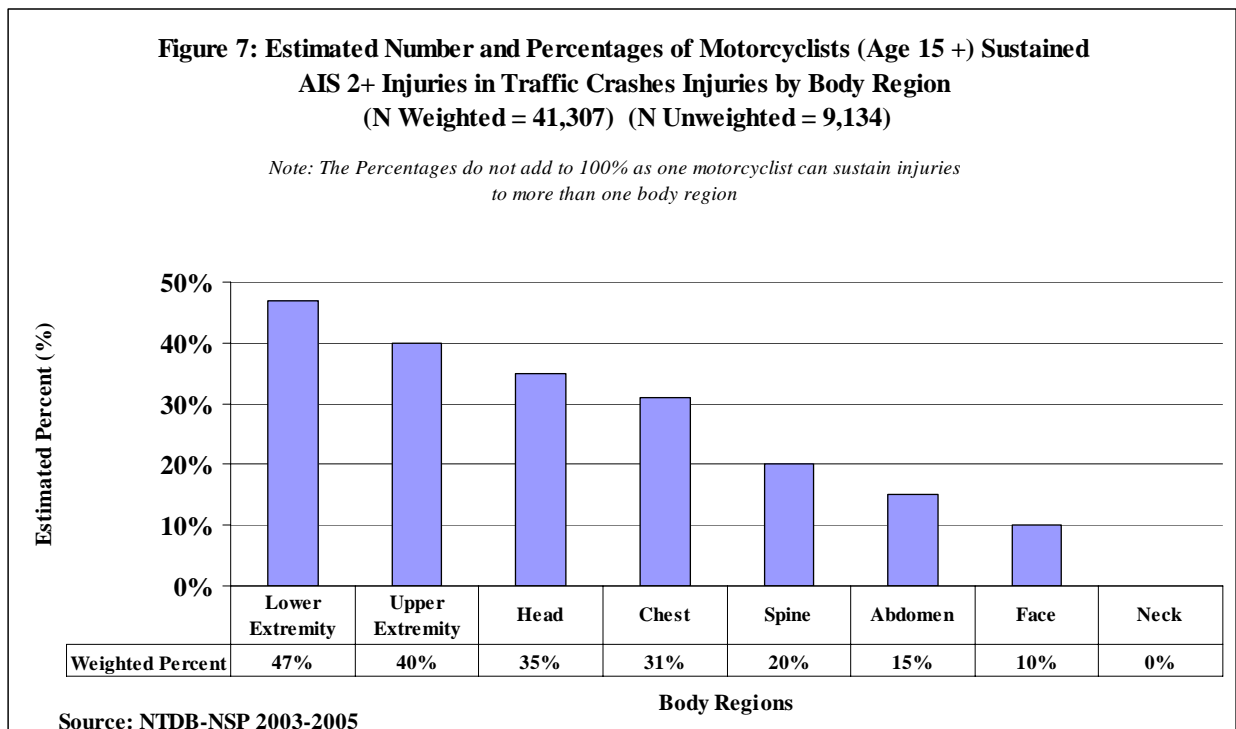
Figure 6: Weighted and Unweighted Number of Motorcyclists and Number of Injuries Sustained Used Throughout the Analysis of the Following Sections of the Report. Source: NTDB-NSP 2003-2005



Injury Severity and Distribution in Trauma Center Patients by Body Region

To assess the distribution of different injuries to different body regions, the estimated total of about 41,000 injured motorcyclists aged 15 years and above who sustained at least one AIS 2+ injury were included in the analysis. After excluding injuries of AIS 1 (minor), we selected the injury with the highest AIS per body region. For example if a patient sustained three head injuries with AIS 2, 3, and 4, and two lower-extremity injuries of AIS 2 and 3, the head injury with AIS 4 and lower-extremity injury with AIS 3 are reported in this section.

Injuries to the lower extremities were the most common injury sustained by motorcyclists treated at level I and level II trauma centers. An estimate of about 19,000 patients sustained lower-extremity injuries of AIS 2+, accounting for an estimated 47 percent of the patients included in the analysis. Upper extremity and head injuries were the second and third most common injuries accounting for 40 and 35 percent of patients, respectively (Figure 7 & Table 2).



Although lower-extremity injuries are more common than head, chest, and abdominal injuries in patients, they remain less severe. As shown in Table 2a, an estimated 97 percent of the lower-extremity injuries were of maximum AIS 2 or 3. Only an estimated 3 percent of the lower-extremity injuries had maximum AIS of 4 or higher compared to 35 percent for the head, 32 percent for the chest, and 21 percent for the abdomen.

Table 2a: Estimated Frequency and Percentage of Maximum AIS Severity Reported for Each Body Region Among Motorcyclists Involved in Traffic Crashes

Body Region		AIS Score					
		AIS-2	AIS-3	AIS-4	AIS-5	AIS-6	Total
Head	<i>Weighted Frequency</i>	5,948	3,383	3,246	1,924	37	14,538
	<i>Weighted Percent</i>	41%	23%	22%	13%	0.3%	100%
Face	<i>Weighted Frequency</i>	3,607	514	29	0	0	4,150
	<i>Weighted Percent</i>	87%	12%	0.7%	0.0%	0.0%	100%
Chest	<i>Weighted Frequency</i>	1,819	6,747	3,577	438	17	12,598
	<i>Weighted Percent</i>	14%	54%	28%	4%	0.1%	100%
Abdomen	<i>Weighted Frequency</i>	3,418	1,486	929	379	3	6,215
	<i>Weighted Percent</i>	55%	24%	15%	6%	<1%	100%
Spine	<i>Weighted Frequency</i>	6,111	1,612	157	409	81	8,370
	<i>Weighted Percent</i>	73%	19%	2%	5%	1%	100%
Upper Extremity	<i>Weighted Frequency</i>	12,769	3,886	0	0	0	16,655
	<i>Weighted Percent</i>	77%	23%	0.0%	0.0%	0.0%	100%
Lower Extremity	<i>Weighted Frequency</i>	8,760	10,030	371	139	0	19,300
	<i>Weighted Percent</i>	45%	52%	2%	1%	0.0%	100%

Source: NTDB-NSP 2003-2005

Table 2b: Unweighted Frequency and Percentage of Maximum AIS Severity Reported for Each Body Region Among Motorcyclists Involved in Traffic Crashes

Body Region		AIS Score					Total
		AIS-2	AIS-3	AIS-4	AIS-5	AIS-6	
Head	<i>Unweighted Frequency</i>	1,479	793	753	463	9	3,497
	<i>Unweighted Percent</i>	42%	23%	22%	13.2%	<1 %	100%
Face	<i>Unweighted Frequency</i>	805	135	6	0	0	946
	<i>Unweighted Percent</i>	85%	14%	<1 %	.0%	.0%	100%
Chest	<i>Unweighted Frequency</i>	394	1,528	800	114	11	2,847
	<i>Unweighted Percent</i>	14%	54%	28%	4%	<1%	100%
Abdomen	<i>Unweighted Frequency</i>	708	339	194	84	2	1,327
	<i>Unweighted Percent</i>	53%	26%	15%	6%	<1%	100%
Spine	<i>Unweighted Frequency</i>	1,265	368	27	88	13	1,761
	<i>Unweighted Percent</i>	72%	21%	2%	5%	<1%	100%
Upper Extremity	<i>Unweighted Frequency</i>	2,821	840	0	0	0	3,661
	<i>Unweighted Percent</i>	77%	23%	.0%	.0%	.0%	100%
Lower Extremity	<i>Unweighted Frequency</i>	1,843	2,168	106	39	0	4,156
	<i>Unweighted Percent</i>	44%	52%	3%	1%	.0%	100%

Source: NTDB-NSP 2003-2005

Level of Lower-Extremity Injuries in Trauma Center Patients

To prioritize the need for intervention according to the frequency of injuries, the lower-extremity injuries were grouped into eight different regions: foot, ankle, leg, knee, thigh, hip, pelvis, and “other” regions. An estimated 19,000 motorcyclists sustained an estimate of about 36,000 lower-extremity injuries with severity of AIS 2+.

An estimated 27 percent of the AIS 2+ lower-extremity injuries encountered by motorcyclists were leg injuries. Pelvic injuries were the second most common AIS 2+ injuries, followed by knee injuries accounting, for 18 percent and 16 percent respectively (Figure 8 and Table 3).

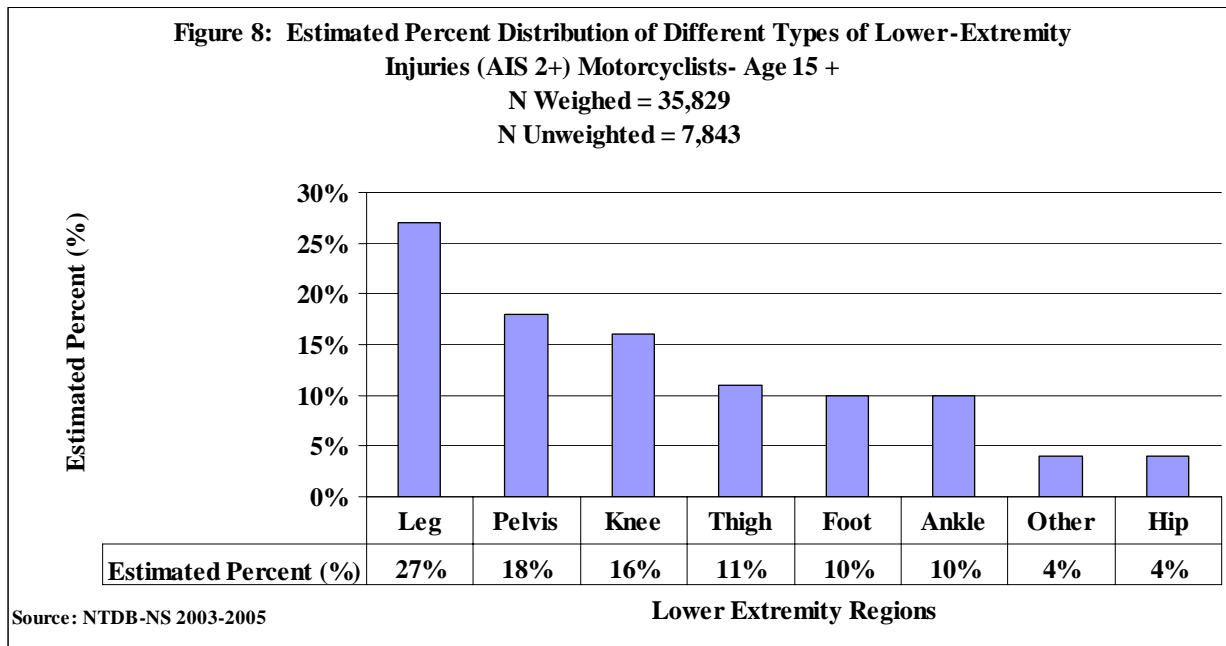


Table 3: Weighted and Unweighted Levels of Lower-Extremity Injuries in Motorcycle Crashes

Level of Lower-Extremity Injury	Weighted Frequency	Weighted Percent	Unweighted Frequency	Unweighted Percent
Leg	9,784	27%	2,157	28%
Pelvis	6,504	18%	1,416	18%
Knee	5,683	16%	1,202	15%
Thigh	3,863	11%	876	11%
Ankle	3,560	10%	798	10%
Foot	3,415	10%	743	10%
Other	1,580	4%	338	4%
Hip	1,440	4%	313	4%
Total	35,829	100%	7,843	100%

Source: NTDB-NSP 2003-2005

Type of Lower-Extremity Injuries Sustained at Different Levels

To understand the mechanism and kinematics of injury to different lower-extremity structures, a detailed analysis of the anatomical structures is provided in this section.

Foot Injuries: Prominent bony structures such as metatarsal or tarsal, calcaneus and talus are the most common foot structures to be injured in motorcycle crashes, and together accounted for more than an estimated 84 percent of foot injuries (Table 4).

Table 4: Estimated Distribution of Different Types of AIS 2+ Foot Injuries, Motorcyclists 15 and Older

Injury Description	Weighted Frequency	Weighted Percent	Unweighted Frequency	Unweighted Percent
Metatarsal or Tarsal Fracture	1,751	51%	397	53%
Calcaneus Fracture	591	17%	127	17%
Talus Fracture	563	17%	118	17%
Foot, Fracture, NFS	475	14%	90	12%
Toe, Amputation/Crush/Degloving	34	1%	11	1%
Total	3,415	100%	743	100%

Source: NTDB-NSP 2003-2005

Ankle Injuries: Tibia and fibula malleolar fractures (prominent bony structures) were the most common ankle injuries, accounting together for an estimated 90 percent of all ankle injuries. Ankle dislocation (with or without involving articular cartilage) accounted for an estimated 9 percent of all ankle injuries (Table 5).

Table 5: Estimated Distribution of Different Types of AIS 2+ Ankle Injuries, Motorcyclists 15 and Older

Injury Description	Weighted Frequency	Weighted Percent	Unweighted Frequency	Unweighted Percent
Fibula, Fracture, Bimalleolar or Trimalleolar	997	28%	220	28%
Fibula, Fracture, Lateral Malleolus	984	28%	237	29%
Tibia, Fracture, Medial Malleolus	692	19%	149	19%
Tibia, Fracture, Medial Malleolus, Open/Displaced/Comminuted	386	11%	83	10%
Ankle, Dislocation, With/Without Involving Articular Cartilage	362	10%	78	10%
Tibia, Fracture, Posterior Malleolus	139	4%	31	4%
Total	3,560	100%	798	100%

Source: NTDB-NSP 2003-2005

Leg Injuries: Tibia and fibula fractures were the most common leg injuries accounting for an estimated 95 percent of all leg injuries. Partial or complete traumatic leg amputations and massive leg crush accounted for an estimated 3 percent of all leg injuries (Table 6).

**Table 6: Estimated Distribution of Different Types of AIS 2+ Leg Injuries
Motorcyclists 15 and Older**

Injury Description	Weighted Frequency	Weighted Percent	Unweighted Frequency	Unweighted Percent
Tibia, Fracture	5,133	52%	1,142	53%
Fibula, Fracture	4,161	43%	908	42%
Leg Amputation/Massive Crush	311	3%	64	3%
Popliteal Artery/Vein	118	1%	25	1%
Achilles Tendon, Laceration	55	1%	16	1%
Leg, Fracture, NFS	8	<1%	2	<1%
Total	9,784	100%	2,157	100%

Source: NTDB-NSP 2003-2005

Knee Injuries: Fractures of tibia plateau and intercondyloid spine accounted for an estimated 37 percent of knee injuries. Fracture of patella was recorded in an estimated 18 percent of the knee injuries. Ligamentous and meniscus tear combined accounted for an estimated 18 percent of all knee injuries (Table 7).

**Table 7: Estimated Distribution of Different Types of AIS 2+ Knee Injuries,
Motorcyclists 15 and Older**

Injury Description	Weighted Frequency	Weighted Percent	Unweighted Frequency	Unweighted Percent
Tibia, Fracture, Plateau/Intercondyloid Spine	2,111	37%	431	36%
Patella Fracture	1,004	18%	209	17%
Collateral or Cruciate Ligament Laceration	704	12%	157	13%
Knee, Dislocation, With/Without Involving Articular Cartilage	541	10%	127	11%
Femur, Fracture, Condylar	486	9%	104	9%
Knee, Sprain	362	6%	74	6%
Knee, Laceration Into Joint	184	3%	39	3%
Knee, Meniscus Tear	147	3%	30	2%
Patellar Tendon Laceration	145	3%	31	3%
Total	5,683	100%	1,202	100%

Source: NTDB-NSP 2003-2005

Thigh Injuries: Femur fractures were the most common thigh injuries, accounting for an estimated 94 percent; femur shaft fractures accounted for an estimated 53 percent of all thigh injuries. Soft tissue injuries such as injuries to thigh arteries, veins, and nerves together accounted for only 4 percent (Table 8).

Table 8: Estimated Distribution of Different Types of Thigh Injuries AIS 2+ Motorcyclists 15 and Older

Injury Description	Weighted Frequency	Weighted Percent	Unweighted Frequency	Unweighted Percent
Femur, Fracture, Shaft	2,027	53%	442	50%
Femur, Fracture, NFS	708	18%	174	20%
Femur, Fracture, Open/Displaced/Comminuted	365	9%	94	11%
Femur, Fracture, Subtrochanteric	320	8%	60	7%
Femur, Fracture, Supracondylar	232	6%	51	6%
Femoral Artery/Vein-Sciatic Nerve Injury	151	4%	39	4%
Above Knee, Amputation Partial or Complete,	60	2%	16	2%
Total	3,863	100%	876	100%

Source: NTDB-NSP 2003-2005

Hip Injuries: Hip dislocation was the most common type of hip injury, accounting for an estimated 37 percent. Intertrochanteric femoral fractures and fracture neck of femur were the second and third most common hip injuries, accounting for an estimated 30 and 25 percent, respectively (Table 9).

Table 9: Estimated Distribution of Different Types of Hip Injuries AIS 2+ Motorcyclists 15 and Older

Injury Description	Weighted Frequency	Weighted Percent	Unweighted Frequency	Unweighted Percent
Hip, Dislocation, With/Without Involving Articular Cartilage	531	37%	114	37%
Femur, Fracture, Intertrochanteric	434	30%	88	28%
Femur, Fracture, Neck	356	25%	85	27%
Femur, Fracture, Head	120	8%	26	8%
Total	1,440	100%	313	100%

Source: NTDB-NSP 2003-2005

Pelvic Injuries: Different forms of pelvic fractures (with or without deformation) accounted for an estimated 69 percent of all pelvic injuries. Symphysis pubis separation was reported in an estimated 17 percent of the pelvic injuries. Sacrollium fracture with or without dislocation was the pelvic injury in an estimated 13 percent of the cases (Table 10).

Table 10: Estimated Distribution of Different Types of Pelvic Injuries AIS 2+ Motorcyclists 15 and Older

Injury Description	Weighted Frequency	Weighted Percent	Unweighted Frequency	Unweighted Percent
Pelvis, Fracture, With or Without Dislocation	4,077	63%	883	62%
Symphysis Pubis Separation (Fracture)	1,116	17%	209	15%
Sacroiliac Fracture With or Without Dislocation	880	13%	200	14%
Pelvis, Fracture, Substantial Deformation and Displacement	430	7%	124	9%
Total	6,504	100%	1,416	100%

Source: NTDB-NSP 2003-2005

Discharge Disposition and Hospital Charges

Discharge Disposition: An estimated total of 37,000 motorcycle riders who sustained AIS 2+ injuries had a known and valid discharge disposition, which is 89 percent of the estimated 41,000 motorcycle riders with AIS 2+ injuries (see Figure 6).

The discharge disposition varies according to the type of lower-extremity injury sustained by motorcyclists. An estimated 81 percent of motorcycle riders who sustained single-isolated lower-extremity injuries were discharged home. On the other hand, an estimated 72 and 45 percent of motorcyclists who sustained multiple lower-extremity injuries or lower-extremity in combination with injuries to other body regions were discharged home without further care, respectively. The need for further rehabilitation increased from an estimated 4 percent for motorcyclists who sustained single-isolated lower-extremity injuries to an estimated 9 percent for those with multiple lower-extremity injuries and an estimated 23 percent for motorcyclists who sustained lower-extremity in combination with injuries to other body regions. These numbers compare to only an estimated 8 percent for motorcyclists without any lower-extremity injuries (Tables 11a and 11b).

Table 11a: Estimated Distribution of Discharge Disposition for Motorcyclists 15 and Older With AIS 2+

Discharge Disposition		Injury Group			
		Isolated Lower Extremity	Multiple Lower Extremity	Lower Extremity and Other Injuries	Non-Lower Extremity
Death	<i>Weighted Frequency</i>	67	47	872	1,118
	<i>Weighted Percent</i>	2%	1%	9%	6%
Discharged- Skilled Nursing Facility (SNF)	<i>Weighted Frequency</i>	46	72	351	124
	<i>Weighted Percent</i>	1%	2%	3%	1%
Home	<i>Weighted Frequency</i>	2,765	2,434	4,596	15,060
	<i>Weighted Percent</i>	81%	72%	45%	77%
Home Health	<i>Weighted Frequency</i>	259	298	1,020	415
	<i>Weighted Percent</i>	8%	9%	10%	2%
Hosp Transfer	<i>Weighted Frequency</i>	73	63	359	259
	<i>Weighted Percent</i>	2%	2%	4%	1%
Nursing Home	<i>Weighted Frequency</i>	32	34	83	52
	<i>Weighted Percent</i>	1%	1%	1%	<1%
Other	<i>Weighted Frequency</i>	70	140	611	1,003
	<i>Weighted Percent</i>	2%	4%	6%	5%
Rehab	<i>Weighted Frequency</i>	119	318	2,381	1,534
	<i>Weighted Percent</i>	4%	9%	23%	8%
Total	<i>Weighted Frequency</i>	3,431	3,406	10,273	19,565
	<i>Weighted Percent</i>	100%	100%	100%	100%

Source: NTDB-NSP 2003-2005

Table 11b: Unweighted Distribution of Discharge Disposition for Motorcyclists 15 and Older With AIS 2+

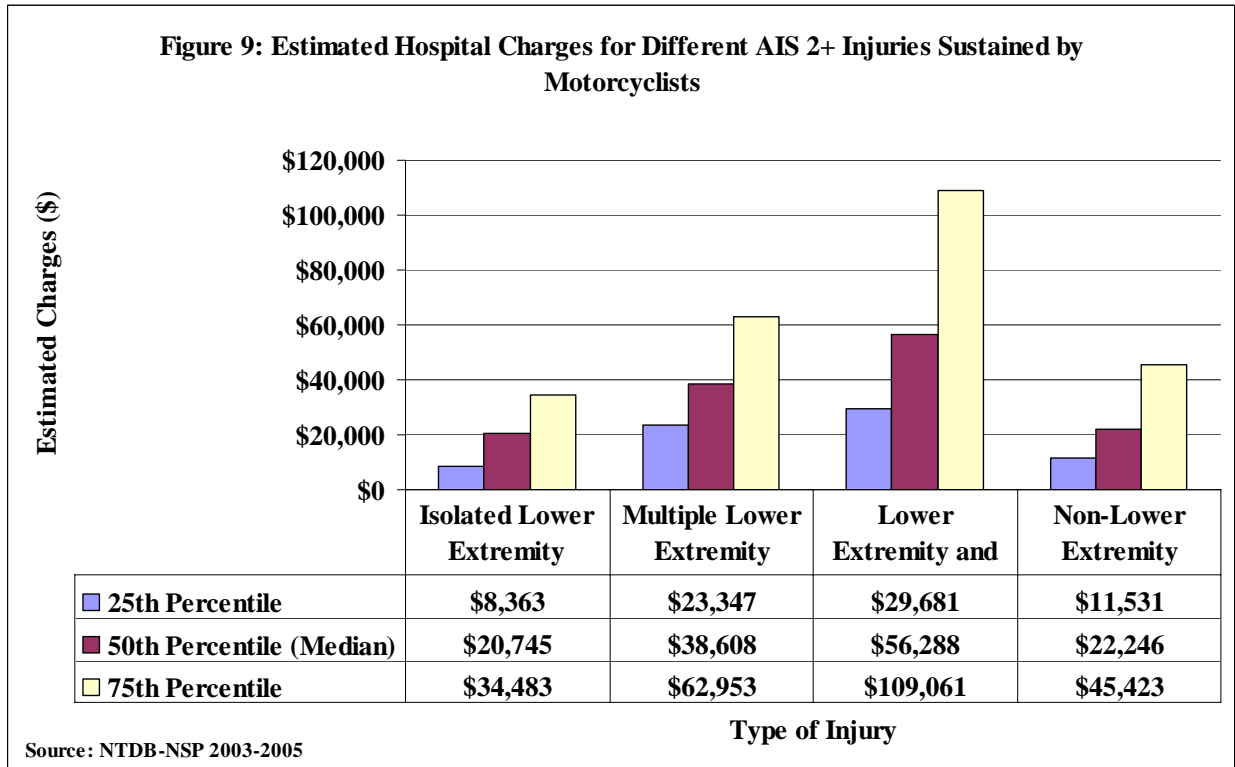
Discharge Disposition		Injury Group			
		Isolated Lower Extremity	Multiple Lower Extremity	Lower Extremity and Other Injuries	Non-Lower Extremity
Death	<i>Unweighted Frequency</i>	12	8	177	260
	<i>Unweighted Percent</i>	2%	1%	8%	6%
Discharged- Skilled Nursing Facility (SNF)	<i>Unweighted Frequency</i>	6	17	87	40
	<i>Unweighted Percent</i>	1%	2%	4%	1%
Home	<i>Unweighted Frequency</i>	564	497	1,020	3,384
	<i>Unweighted Percent</i>	82%	70%	47%	77%
Home Health	<i>Unweighted Frequency</i>	40	66	157	77
	<i>Unweighted Percent</i>	6%	9%	7%	2%
Hosp Transfer	<i>Unweighted Frequency</i>	17	19	86	71
	<i>Unweighted Percent</i>	3%	3%	4%	2%
Nursing Home	<i>Unweighted Frequency</i>	5	7	25	15
	<i>Unweighted Percent</i>	1%	1%	1%	<1%
Other	<i>Unweighted Frequency</i>	14	26	111	207
	<i>Unweighted Percent</i>	2%	4%	5%	5%
Rehab	<i>Unweighted Frequency</i>	32	75	522	363
	<i>Unweighted Percent</i>	5%	11%	24%	8%
Total	<i>Unweighted Frequency</i>	690	715	2,185	4,417
	<i>Unweighted Percent</i>	100%	100%	100%	100%

Hospital Charges: Medians and percentiles of hospital charges as an indicator of injury complexity and severity were calculated. Hospital charges were calculated for motorcyclists who sustained single-isolated lower-extremity injuries, multiple lower-extremity injuries, lower-extremity in combination with injuries to other body regions and those without any lower-extremity injuries.

Only an estimated 42 percent of the motorcyclists who sustained AIS 2+ injuries had known and valid hospital charges (17,000 out of 41,000). The availability of hospital charges varied only slightly according to the type of injury sustained. The availability of hospital charges were 41 percent, 47 percent, 44 percent, and 41 percent for patients with isolated lower-extremity, multiple lower extremities, lower-extremity and other injuries and non-lower-extremity, respectively (Figure 6). Although there is no reason to believe that the unknowns vary substantially from the known values, this section reports quartile statistics, which are less likely to be affected by particularly large (or small) values that may occur in either the known or unknown data.

As shown in Figure 9 and Tables 12a and 12b, hospital charges were the highest when motorcyclists sustained lower-extremity in combination with injuries to other body region.

Twenty-five percent of motorcyclists who sustained lower-extremity in addition to other injuries had hospital charges of an estimated \$109,000 or more. The estimated median hospital charges for motorcyclists who sustained lower-extremity in addition to other injuries are approximately \$56,000. Motorcycle riders who sustained multiple lower-extremity injuries had the second highest hospital charges at an estimated median of approximately \$38,000 and 25 percent of the group with hospital charges of \$63,000 or more.



**Table 12a: Estimated Hospital Charges for Different AIS 2+ Injuries Sustained by Motorcyclists
NTDB-NSP 2003-2005**

Injury Group	Frequency	25 th Percentile	50th Percentile (Median)	75th Percentile
Isolated Lower-Extremity	1,599	\$8,363	\$20,745	\$34,483
Multiple Lower-Extremity	1,808	\$23,347	\$38,608	\$62,953
Lower-Extremity and Other Injuries	5,065	\$29,681	\$56,288	\$109,061
Non-Lower-Extremity	9,009	\$11,531	\$22,246	\$45,423
Total	17,480	\$14,980	\$30,855	\$64,078

**Table 12b: Unweighted Hospital Charges for Different AIS 2+ Injuries Sustained by Motorcyclists
NTDB-NSP 2003-2005**

Injury Group	Frequency	25 th Percentile	50th Percentile (Median)	75th Percentile
Isolated Lower-Extremity	375	\$11,414	\$21,539	\$34,534
Multiple Lower-Extremity	425	\$22,065	\$37,957	\$64,578
Lower-Extremity and Other Injuries	1185	\$28,831	\$55,270	\$109,733
Non-Lower-Extremity	2305	\$12,766	\$23,145	\$47,299
Total	4,290	\$15,684	\$30,518	\$65,618

Payors for Motorcycle Injury Hospitalization

In NTDB-NSP, an estimated 79 percent (33,000/41,000) of motorcyclists with AIS 2+ injuries had a known payor source (see Figure 6). Commercial health insurance plans including Blue Cross/Blue Shield, Managed Care Organization, and CHAMPUS (The Civilian Health and Medical Program of the Uniformed Services) paid for an estimated 40 percent of the hospital charges. Automobile insurance paid for an estimated 19 percent of the injured motorcyclists. However, an estimated 20 percent did not have any source of health insurance and were coded as self-pay. Medicaid and Medicare combined paid for an estimated 7 percent of the patients included in the analysis (Figure 10 and Table 13).

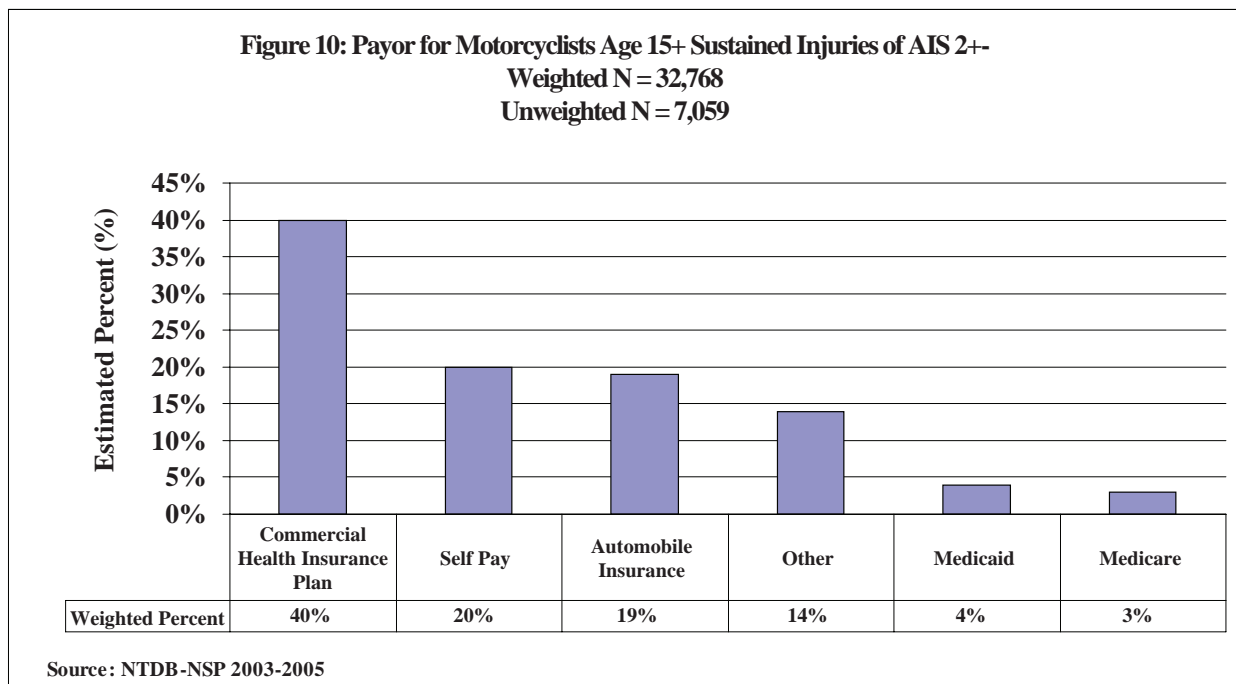


Table 13: Payors for Motorcyclists Sustained AIS 2+ Injuries in Traffic Crashes

Payor	Weighted Frequency	Weighted Percent	Unweighted Frequency	Unweighted Percent
Commercial Health Insurance Plan	13,093	40%	2,955	42%
Self-Pay	6,588	20%	1,379	20%
Automobile Insurance	6,113	19%	1,136	16%
Other	4,559	14%	1,064	15%
Medicaid	1,283	4%	304	4%
Medicare	1,131	3%	221	3%
Total	32,768	100%	7,059	100%

Source: NTDB-NSP 2003-2005

CONCLUSION

The number of registered motorcycles in the United States has increased by 75 percent in 2006 compared to 1997. Following the increase in registered motorcycles, the number of motorcyclists involved in crashes has increased by 62 percent in 2006 compared to 1997. Most of the incapacitating injuries were sustained when the front of the motorcycle was the initial point of impact. However, 30 percent of the incapacitating injuries were in crashes where the motorcycle did not strike another vehicle or a fixed object, such as a crash where the motorcycle falls to the ground. Similarly, fatal injuries most often occurred when the initial point of impact was the front of the motorcycle. These findings aim to guide researchers in exploring new protective countermeasures to prevent these types of serious injuries related to motorcycle crashes. Furthermore, more exploration of the noncollisions may be warranted because these may be the crashes most likely to result in lower-extremity injuries due to the nature of the crash.

Lower extremities are the body region most frequently injured among motorcyclists treated in trauma centers during the 2003-2005 period examined, and it is likely that the estimated 16,000 motorcyclists per year treated in trauma centers for moderate or more severe injuries are similar to the estimated 25,000 motorcyclists with incapacitating injuries from the 2006 NASS/GES. The results of this study suggest that lower-extremity injuries are the most common injuries sustained by motorcyclists in crashes. Within that anatomical region, leg injuries are the most frequent. Pelvic and knee injuries were the second and third most common lower-extremity injuries. Long-bone fractures of the tibia, fibula, and femur were the most common lower-extremity injuries.

The mechanism of different lower-extremity injuries is not well understood. The clinical diagnosis of different lower-extremity injuries in this study aims to provide the biomechanics researchers the basis to identify the mechanism of these injuries and prioritize the need for intervention based on the frequency and severity of injuries. Understanding the type and frequency of different lower-extremity injuries in motorcycle crashes would also provide a foundation for computer simulation and innovations of countermeasures to prevent these types of injuries.

Lower-extremity injuries are nonfatal most of the time, as indicated by the fact that an estimated 98 percent of motorcyclists who sustained single-isolated injuries and an estimated 99 percent who sustained multiple lower-extremity injuries survived their injuries. Lower-extremity injuries often lead to extended and costly medical treatment and permanent disability. In addition, the need for rehabilitation increases from 4 percent for single-isolated lower-extremity injuries to 9

and 23 percent for motorcyclists sustaining multiple lower-extremity injuries and lower-extremity in combination to other injuries, respectively.

Although the immediate acute hospitalization costs of motorcycle crash injuries have been examined, the longer-term costs of injury rehabilitation have not been fully addressed. To compensate for the lack of information on the cost of long treatment and possible disability, more detailed data are needed to estimate the total cost of lower-extremity injuries and calculate the work-days lost due to the short-term and long-term disabilities.

Motorcycle crashes carry a financial burden on motorcyclists, the community, and the treating health care facilities. This study showed that an estimated 20 percent of the motorcyclists treated in trauma centers did not have any source of health insurance and an estimated 7 percent were paid for by the government funded resources such as Medicaid and Medicare programs.

More biomechanical studies are needed to examine the mechanism of different lower-extremity injuries and identify the necessary modifications in motorcycle design and motorcyclists apparel that might prevent lower-extremity injuries in motorcycle crashes.

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