A DESCRIPTION OF MOTORCYCLE CRASH INJURIES AND HELMET USE IN A SAMPLE OF MARYLAND TRAUMA PATIENTS

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ABSTRACT - Despite declines in the overall number of traffic related fatalities on the nation's roadways, there continues to be a significant increase in mortality among motorcyclists. Most studies have focused primarily on fatalities, comparing riders with and without helmets, and trends in head injury following repeal or passage of motorcycle helmet laws. Little information is available regarding the type or quality of the helmet worn. This study describes the overall characteristics of motorcycle crashes focusing specifically on motorcycle operators who were injured in a roadway crash. In addition to identifying the injury patterns resulting from a crash, information is collected on helmet type and compliance, rider characteristics, and outcome information using the SF-36. The most common injuries sustained by the motorcycle operators were to the lower extremity (39%), upper extremity (33%), and head/face (27%). In addition to the injury patterns identified, 118 motorcycle operators provided answers to a general questionnaire. Ninety-seven percent of the operators were men with a mean age of 38 years. Sixty percent had reported participating in a motorcycle safety training course and the type of motorcycle was evenly distributed between cruisers (37 percent) and sport bikes (39 percent). Thirty-seven percent of the crashes involved a collision with another vehicle. Additionally, while two-thirds reported to be wearing some type of protective clothing, in addition to their helmet, at the time of their crash 20% of the helmets were identified as being non-compliant with current federal standards. By analyzing riders who sustained a head injury, this analysis suggests that the likelihood of sustaining a brain injury increases for motorcycle operators wearing a non-compliant helmet as compared to operators wearing a compliant helmet.

INTRODUCTION

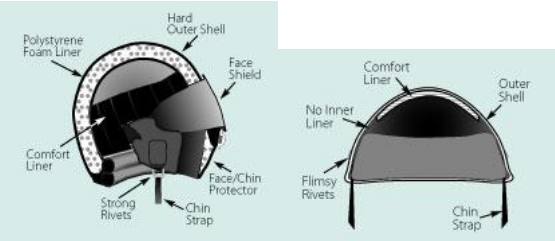
Motorcycles have become an increasingly popular mode of transportation; motorcycle registrations in the United States topped 8.1 million in 2007 [1], more than doubling the number of registrations a decade prior. Motorcyclists are particularly vulnerable to injury because their vehicles provide little or no protection in the event of a crash. Helmets have repeatedly been proven to reduce the severity of head injury in crashes [2-6]. Helmets have shown a protective effect for brain injuries or skull fractures, and have also been shown to reduce overall mortality.[8-9] However, the number of U.S. motorcyclists injured (103,000) and killed (5,154) in 2007 continued a ten year upward trend[7].

During this same period, there has been an increase in the average engine size of motorcycles, from a mean of 769 cc in 1990 to 999 cc in 2002 [14]. Also, in 1995 Congress lifted sanctions against states without universal helmet laws and in the 8 years following, a total of 6 states modified their helmet laws, reducing their restrictions (Texas, Arkansas, Kentucky, Louisiana, Florida, Pennsylvania).[15] When comparing states with a universal helmet law and those with a modified law or none at all, observed helmet use rates are significantly different. Studies have shown helmet use to approach 100% in states with a universal law and only 50% where either no law or one applying only to some riders exists. [16-17] While the use of a motorcycle helmet has been estimated to be 37 percent effective in preventing fatal injuries to motorcyclists who are involved in a highway crash, only 59 percent of motorcyclists who sustained fatal injuries were reported to be wearing a helmet at the time of their crash.[18]

The US DOT created Federal Motor Vehicle Safety Standard FMVSS No. 218 in 1973 to outline the structural requirements needed to classify a helmet as safe and protective in relation to traffic crashes. A recent study has suggested revisions to the FMVSS No. 218 testing standards because the current threshold allows for a high probability of head injury[15]. However, despite the passage of mandatory helmet laws in a number of states, anecdotal evidence suggests the use of 'novelty' helmets that do not meet the requirements of FMVSS No. 218 remains steady (Illustration 1).

The use of these non-compliant helmets may satisfy the state law and help avoid a citation but they offer little to no protection in the event of a crash.[17]

Illustration 1 – Characteristics of FMVSS 218 Compliant and Non-compliant (novelty) Helmets



Compliant Helmet Novelty Helmet

This study provides a general description of the characteristics of motorcycle crashes in Maryland and the injury patterns associated with those crashes among a sample of motorcyclists admitted to a Level I trauma center. It also documents the prevalence of 'novelty' helmet use and association between type of helmet and head injury severity among motorcycle operators in Maryland who were transported to a trauma center as the result of a highway crash.

**Data update – Statistics released from the National Highway Traffic Safety Administration (DOT HS 811 765) revealed a total of 4,612 motorcyclist fatalities in 2011, a slight increase over the previous year. Additionally, the National Occupant Protection Use Survey showed that the use of DOT-compliant motorcycle helmets was at 67 percent in 2009 (DOT HS 811 254)

METHODS

The Maryland Automated Accident Reporting System (MAARS) collects data on more than 100,000 crashes that occur annually. An analysis of this database was used to provide a general description of the number and type of motorcycle crashes that occur in the state. While the MAARS report collects the speed limit of the roadway section on which the crash occurred, little additional information is collected on the severity of the crash or the speed at which the motorcycle may have been traveling prior to the event. No delta-v or other surrogate for crash force is collected. Information on injuries and helmet type was collected from persons who were transported to the STC as a result of their crash during the period January 2007 through May 2008.

During the course of their hospital stay, these injured motorcyclists were approached and asked to provide consent for participation in the study. Upon consent, they were given a questionnaire that asked about their riding habits, the type of crash in which they were involved, their general health, and activity level prior to their crash.

If available, the helmet they were wearing at the time of the crash accompanied the patient to the hospital and was photographed. These photographs were used to identify any damage that may have resulted from the crash and to classify the helmet as being DOT-compliant or not. Severity of damage (e.g. scratches, dents, cracks) was documented with photographs but was not coded for inclusion in this analysis. Specific damage, such as location, number and length of scratches was not quantified.

Demographic characteristics and the nature and extent of the injuries sustained were captured from the STC trauma registry database. For this analysis, any documented brain or skull injury with a severity of 1 or higher, using the Abbreviated Injury Scale (AIS), was classified as a head injury.

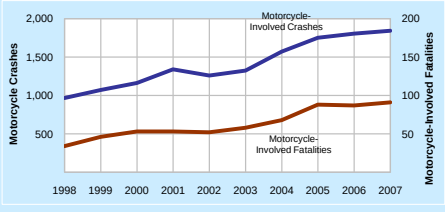
The following results are based on analysis of the individual sets of data that were collected for this study. A completely integrated database combining information from the crash, hospital, interview and helmet data was not constructed.

RESULTS

Crash Characteristics

During calendar year 2007 there were 1,841 police-reported motorcycle crashes and 96 fatalities that occurred on Maryland roads. These crashes involved a total of 1,896 motorcycle operators. Both numbers continue an upward trend in both crashes and fatalities that extends back to the late 1990's (Figure 1). Nationally, the fatality rate per 100,000 registered vehicles increased by over 30% between 1997 and 2006.[20]

Figure 1 – Trends in MD Motorcycle Crashes (1998-2007)



The vast majority of the motorcycle operators involved in a crash statewide were men (89 percent) and persons between the ages of 35 and 49 accounted for 34 percent of the injured riders More than 40 percent of the crashes occurred on the weekend (Saturday – Sunday) and 60 percent occurred between the hours of noon and 8pm. While 64 percent of the total crashes occurred in an area where the speed limit was less than 40 mph, just over half (50.6%) of the fatal crashes occurred on a roadway where the speed limit was 50 mph or greater.

Table 1 – Maryland Motorcycle Crash and Operator Characteristics (2007)

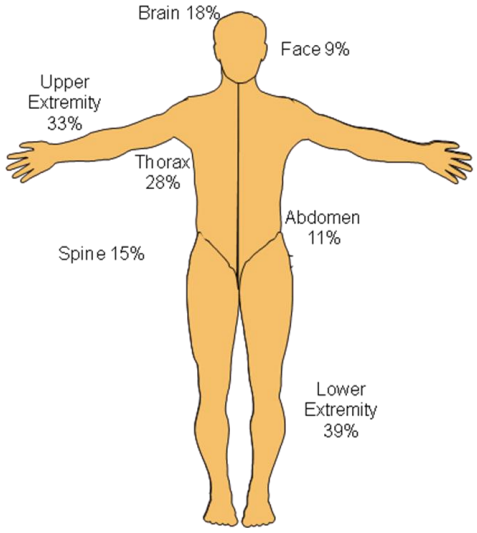
Total Operators Involved in Crashes (n=1,896)				Operators Killed in Crashes (n=88)	
	N	%		N	%
Gender					
Male	1,680	89		87	99
Age					
<20	106	5.6		5	5.7
20-34	672	35.5		33	37.5
35-49	653	34.6		35	39.8
50-64	320	16.9		12	13.6
65+	32	1.7		3	3.3
Unknown	113	6.0		0	0.0
Helmet Use					
Yes	1,403	74.0		77	87.5
No	162	8.6		5	5.6
Unknown	331	17.5		6	6.8
Total Motorcycle Crashes (n=1,841)				Fatal Motorcycle Crashes (n=91)	
Day of Week					
Weekday	1,046	56.8		49	53.8
Weekend	795	43.2		42	46.2
Hour of Day					
12am – 8am	231	12.5		12	13.2
8am – 12pm	199	10.8		6	6.6
12pm – 8pm	1,105	60.0		54	59.4
8pm – 12am	305	16.6		19	20.9
Unknown	1	0.1		0	0.0
Posted Speed Limit (mph)					
25 or less	336	18.3		6	6.6
30-40	842	45.8		37	40.7
45-50	326	17.7		22	24.2
55+	262	14.3		24	26.4
Unknown	75	4.1		2	2.2

Injured Motorcycle Operators

From January 2007 through May 2008 there were 517 motorcycle operators admitted to the STC as the result of a roadway crash. The mean age of this group was 37 years and 18 percent sustained a brain injury. The distribution of injuries (AIS 2+) to other body regions for this group is illustrated in Figure 2.

Injuries to the upper and lower extremities, as expected, were observed most frequently. The mean Injury Severity Score (ISS) was 14.5 (range 1-75). Among this group of patients, 244 (47 percent) of those motorcycle operators who arrived at the trauma center had a sufficient length of stay for data collection, a Glasgow Coma Score of 15, and provided consent to have photographs taken of the helmet they were wearing at the time of the crash. Based on these photographs, 20 percent of these helmets were identified as novelty (or DOT non-compliant) helmets.

Figure 2 – Distribution of Motorcyclist Injuries



Additionally, 118 motorcycle operators provided answers to a general questionnaire that provided information on their demographics, education level, and riding behavior. Selected characteristics of this group are provided in Table 2. Ninety-seven percent of the operators were men with a mean age of 39 years. Nearly 40 percent reported never having taken a motorcycle safety training course and the type of motorcycle ridden was distributed largely between cruisers (37 percent) and sport bikes (39 percent). Thirty-seven percent of the crashes involved a collision with another vehicle. Additionally, 65 percent reported to be wearing some type of protective clothing (excluding long pants/jeans) at the time of their crash.

As shown in Table 2, only 80% of helmets obtained in this study were found to be compliant with FMVSS

218. Those operators wearing 'novelty' helmets at the time of their crash were found to be significantly older (46.9 years vs 37.3 years, $p<.05$). A comparison of brain injury and helmet type revealed that 56 percent (28/50) of those wearing a non-compliant helmet sustained a brain injury (AIS 1-6) as compared to 19 percent (37/194) of those wearing a compliant helmet ($p<.05$).

Table 2 – General Participant Characteristics (N=118)

	Percent
Gender	
Male	97
Education Level	
HS Diploma or less	45
Motorcycle Type	
Cruiser	37
Sport	39
Taken a MC training course	
No	39
Type of Crash	
Laid bike down	20
Single vehicle, object impact	31
Multiple vehicle	
Intersection related	16
Non-intersection related	21
Type of Road	
Interstate	21
City street/urban area	15
Suburban area	26
County road/rural area	29
Protective Clothing worn	65
Helmet Compliance	
FMVSS 218 Compliant	80
Helmet Type	
Full face	55
Three-quarter	10
Half-shell	35

Table 3 shows the association between brain injury and the use of compliant and non-compliant helmets. Motorcycle operators were categorized by the Maximum Abbreviated Injury Severity (MAIS) score.

The table clearly shows higher percentages of riders wearing non-compliant helmets sustained head injuries overall; this difference is especially noted among MAIS 1-4. There is little difference among MAIS 5 head injuries because these are most likely fatal, so regardless of helmet use, patients suffering those injuries will not survive to admission at the trauma center.

Table 3 – Helmet Use and Head/Brain MAIS among Motorcycle Operators

Head/Brain MAIS	1	2	3	4	5
Compliant (n=194)	3%	4%	6%	3%	3%
Non-compliant (n=50)	16%	12%	16%	10%	2%

DISCUSSION

Over the past ten years, there has been a steady and disconcerting increase in motorcycle crashes and fatalities in the U.S. This national trend is also occurring in the state of Maryland. Maryland has a universal helmet law, requiring that all riders wear a DOT-compliant helmet. This law initially helped reduce the incidence of head injuries and fatalities from those injuries[16]; however the increasing popularity of non-compliant helmets and the increase in the number of motorcycles on the highway has contributed to the overall upward trend of injuries and fatalities. Anecdotally, some riders prefer the appearance and feel of these novelty helmets or may wear them to satisfy the minimum requirements of the law. Whatever the reason, the non-compliant helmets do not provide the same level of protection because the FMVSS No. 218 standards are based on thickness, energy absorbing foam, and composition of the shell and are less likely to protect the operator from a brain or skull injury in the event of a crash [17]. This hypothesis has been supported by the research presented here. Of all injured riders, those wearing a non-compliant helmet were more likely to have sustained a head injury.

LIMITATIONS

There are several limitations associated with the current analysis. Aside from using speed limit of the roadway on which the crash occurred as a surrogate, there is no measurement of delta-V to indicate the degree of force

involved in the crash. Damage to the helmets has been documented with photographs but has not been quantified with regard to extent or severity. With regard to the SF-36, follow-up interviews are still being conducted and the outcome measures have not been linked to specific injuries or helmet use.

CONCLUSIONS

It has been shown that there are several distinct groups within the motorcycle riding community.[18] Some studies have separated riders based on age, motorcycle type or riding experience. Younger riders are more likely to ride sport bikes, are often involved in speed-related crashes, and are more likely to purchase the more expensive, compliant helmets. Older riders, on the other hand have been shown to be more likely to ride cruisers, to travel in groups at lower speeds, and to not purchase compliant helmets.

This study has provided a summary of the characteristics of motorcycle crashes and has focused on a sub-group of motorcycle operators who were injured and admitted to a Level I trauma center. Analyses of this trauma center population compared the occurrence of brain injuries with the helmet type, DOT-compliant vs. non-compliant. The findings show that the likelihood of sustaining a brain injury increases when wearing a non-compliant helmet. These helmets do not have the thick protective structure required in FMVSS No. 218, a component that can be directly related to the incidence of head injuries resulting from a crash. Although these findings may be expected, this is the first study, to our knowledge, to examine the association between helmet type and severity of head injury, providing further evidence regarding the effectiveness of DOT-compliant helmets.

Across the country, compliance rules are not always clear for the use of FMVSS-218 compliant helmets, offering motorcycle operators the ability to use novelty helmets to avoid a citation in states with mandatory helmet laws. This study exemplifies the use of the recommendation made in the Review of State Motorcycle Safety Program Technical Assessments[19] that combining multiple datasets provides the opportunity to evaluate various aspects of motorcycle crashes and their subsequent injuries.

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