ORIGINAL RESEARCH

ILBME-80: Analysis of Injury and Resource Utilization Trends in Motorcycle Collisions: A Retrospective Study

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Abstract

Introduction: Florida law Title XXII 316.211 3b allows motorcycle and motor scooter riders to ride without a helmet if they are over the age of 21 or carry an insurance policy providing at least $10,000 in medical benefits for crash injuries. We evaluated the specific injury patterns and associated costs of 150 consecutive patients treated at a level I trauma center in Florida for a motorcycle crash to show clinical trends, evaluate hospital resource utilization, and quantify the financial burden of care.

Materials and methods: We reviewed 150 consecutive adult motorcycle and scooter collision patients treated at a safety-net level I trauma center in Florida between 28th February 2017 and 19th July 2017. We recorded the abbreviated injury scale (AIS) and injury severity scores (ISS) and classified injuries with an Injury Severity Score (ISS) >15 as severe. We assessed the use of computed tomography (CT) scans, magnetic resonance imaging (MRI), and hours spent in the operating room (OR) and converted these services to monetary value to calculate the financial burden of care. The first hour in the OR carried a cost of $6,381 and each subsequent hour had a cost of $4,157. The average cost of a CT was $1,565 and the average cost of an MRI was $2,048.

Results: The most common severely injured area in our patients was the extremities, followed by the head and chest. Patients wearing helmets had fewer severe head and face injuries. The proportion of patients discharged to a skilled nursing facility or experienced inhospital mortality was significantly higher in those with ISS scores classified as severe or highly severe. Similarly, patients with an ISS score classification of severe had higher average use of OR time, CT scans, number of surgeries, and consultations.

Conclusion: Severe injuries were the costliest due to greater OR use, CT scans, and consultations. Legislation that would require proper helmets, gear, and personal injury insurance coverage would help decrease the burden of injury and reduce the financial burden on hospitals.

Keywords: Blunt trauma, Cost, Helmet, Motorcycle, Public health, Scooter, Trauma.

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Introduction

According to the World Health Organization, riders of motorized two- and three-wheeled vehicles account for 28% of all road traffic deaths.[1] In the United States in 2020, motorcyclists in the state of Florida accounted for 2.4% of crashes but 16.6% of fatalities.[2] The state of Florida does not have a universal motorcycle helmet law. As of 2000, Florida law only requires riders to wear a helmet while riding two or three-wheeled vehicles if they are under the age of 21 or lack $10,000 of health care coverage.[3] Florida continually ranks in the top three states for motorcycle fatalities and continues to be one of the states with the highest hospital costs in treating patients with motorcycle injuries.[4] In 2018, the median hospital charge for motorcyclists admitted to a Florida hospital for treatment of collision injuries was $111,830.50.[5,6] Although extensive work has been done to quantify the negative outcomes of motorcycle crashes in terms of injury severity, morbidity, and mortality, very little has been done to elucidate and quantify the costs of these crashes and the burden of care.

Our objective was to investigate the sources of cost of motorcycle crash injuries and to quantify the financial burden to our hospital system.

Materials and Methods

This was an unmatched retrospective cohort study of 150 consecutive adult motorcycle and scooter collision patients treated at a public level I trauma center in a large metropolitan county in South Florida between February and July of 2017. Demographic information, injuries, procedures performed, medical services provided, final disposition, and readmission data were collected from the hospital trauma registry and the hospital's electronic medical records. The cost for hours of OR time was collected from Childers et al.[7] Data from Florida hospital reimbursements by Sistrom and McKay was used to calculating the cost of imaging and procedures.[8] All costs presented are in United States Dollar currency (Table 1).

The cohort included trauma patients greater than 18-year-old that were treated at our trauma center for injuries sustained as a driver or passenger in a motorcycle or scooter crash within the timeline stated above. Patients who were under the age

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Table 1: Rider demographics

	Helmeted	*Unhelmeted*	*All*
N	*53*	*91*	*150*
Age (years)			
Mean	32.5	34.9	33.3
Range	18–70	17–63	17–70
Sex			
Male (%)	52 (92)	78 (86)	135 (90)
Female (%)	1–(2)	11–(12)	15–(10)
Race			
Black (%)	7 (13)	21 (23)	32 (23)
Range (%)	45 (85)	67 (74)	115 (77)
Other (%)	1 (2)	2 (2)	3 (2)
Age (years)			
Mean	36 (68)	47 (52)	84 (56)
Range	17 (32)	43 (47)	66 (44)

of 18 and those who died at the scene of the crash were not included. Demographic data collected included age, sex, health insurance status, helmet status, and past medical history. Injuries and procedures performed were determined by International Classification of Diseases, 10th Revision codes. Resource utilization was defined by imaging studies, inhospital auxiliary services, interventional procedures, and total time in the OR. Injuries were assessed using Abbreviated Injury Scale (AIS) scores and ISS from the trauma registry. We then mapped the most severely injured body region based on the AIS classification system (head/neck, face, abdomen/pelvis, extremities, and external) for each patient and classified ISS scores by using the accepted ISS trauma scoring cutoff values of <8 as "mild," 8–16 as "moderate," 16–24 as "severe," and >24 as "highly severe."[6,9]

Assessment of the cost of CT and MRI, as well as the average time spent in the OR for each patient, was used to calculate the financial burden of care for our patient population. Using hospital cost data reported by Childers et al., it was determined that the first hour in the OR costs $6,381, and each subsequent hour costs $4,157.[7] Mean (M) charge for radiological procedures in Florida hospitals was reported by Sistrom and McKay and showed that the M cost of a CT is $1,565 and the M cost of an MRI is $2,048.[8] From this, we calculated the approximate burden of care for consumption of the most common resources utilized by our patient population.

We report the central tendencies of our continuous variables as M and standard deviation (SD), and categorical variables are reported as proportions of the overall population or proportions within their stratified group as per the concepts of central limit theorem[10] (i.e., the sampling distribution of a sample M is assumed as normal if the sample size is large enough, even in the population distribution is not normal). Chi-squared correlation testing was used to examine the relationship between helmet use, location of most severe injury, final patient disposition, and use of different resources. Factors correlating with final patient disposition, such as injury location and injury severity, were also calculated using Chi-squared tests. Independent *t*-testing was used to examine the relationship between the use of resources and injury severity. For all performed statistical tests, a p-value < 0.05 was considered significant. We used Microsoft Excel to collect and organize our data, and analysis was conducted using Statistical Package for the Social Sciences 28.0.

Results

Initial demographic distribution of the 150 patients in our study showed that most riders were not wearing a helmet (60.67%). The M age of our patients was 36.39 ± 13.82 years, the majority were male (90%) and identified as Hispanic or non-Hispanic white (52 and 25%, respectively), and 44% did not carry any insurance at the time of the crash (Table 2). There was no difference in demographic characteristics when stratified by helmet status except for sex, where the difference in helmet usage by females in both the overall population and stratified groups was significant. In addition, injury pattern analysis showed that in the overall population, the most common area of severe injury was the extremities (35.5%), followed by head/neck (31.3%) and chest (15.3%). When stratified by helmet use, the most common area of severe injury remained as the extremities, followed by head/neck for helmeted riders. However, in the nonhelmeted patients, the most common area of severe injury was the head/neck, followed by extremities (Table 2).

An overview of consumed resources by this cohort shows that the overall population required an average of 3.19 ± 4.96 hours of OR time, 2.15 ± 1.7 consults, 6.07 ± 3.23 CT scans, and 3.09 ± 3.30 visits at an outpatient follow-up or rehabilitation center (Table 3). We found that the average cost of treating a motorcycle crash in our trauma center was $15,484.80 for the use of OR time, $9,499.50 for the use of CT scans, and $307.20 on average for MRI use. The total incurred cost per patient for these services was $25,291.50. This average total does not include other patient-centered costs of treatment at our center including, but not limited to, consulting services and auxiliary inpatient services such as inpatient rehabilitation or other hospital costs related to inpatient admission.

Our overall population did not have a significant difference in the distribution of severity of injury per the ISS classification (Table 4). However, patients with an ISS classification of severe or highly severe had higher average utilization of resources and activation of auxiliary services (Table 4). When comparing discharge disposition, the severely and highly severely injured groups were more likely to require discharge to a skilled nursing facility or experience inpatient death compared to the mild or moderately injured groups (Tables 5 and 6).

Discussion

Due to high injury severity, trauma center hospitalization following a motorcycle crash is associated with higher utilization of costly resources, such as imaging and OR time. However, the severity of injuries could be mitigated by helmet use, as fewer helmeted riders have head, neck, and face injuries. Our data corresponds to findings by Kraus et al., in that an increase in helmet compliance decreased the prevalence of head injuries in this patient population.[11] It has been reported that a significantly higher proportion of patients with head and neck injuries die in the hospital when compared to patients with extremity injuries.[11,12] We found that patients with extremity injuries are more likely to survive but utilize more resources and incur higher costs. In addition, due to disability at the time of discharge, more patients with severe injuries required a skilled nursing facility or inpatient rehabilitation as their discharge disposition.[1113]

Table 2: Rider demographics and comparison of patient coverage, injury pattern, and disposition by helmet status

		Helmet status			
	Overall population	*Helmet*	*No helmet*	*Unknown*	*p-value*
Total *N* (%)	150 (100)	53 (35)	91 (61)	6 (4)	
Patient demographics					
N		53	91	6	
Age (years)					
Median (IQR)	36.39 (13.82)	31 (24)	35 (23)	30 (27)	
Age range		18–70	17–63	20–60	
Sex *N* (%)					0.015**
Male	135 (90)	52 (38.5)	78 (57.8)	5 (3.7)	
Female	15 (10)	1 (6.7)	13 (86.7)	1 (6.7)	
Race N (%)					
White	115 (76.7%)	45 (39.1)	67 (58.3)	3 (2.6)	
Black	32 (21.3%)	7 (21.9)	22 (68.8)	3 (9.4)	
Other	3 (2.0%)	1 (33.3)	2 (67)	0	
Ethnicity *N* (%)					
Hispanic	84 (56.0%)	36 (43)	47 (56)	1 (1)	
Non-Hispanic	66 (44.0%)	17 (26)	44 (67)	5 (7.6)	
Insurance status *N* (%)					
Commercial	52 (34.7)	19 (35.8)	30 (33)	3 (50)	
Medicaid	24 (24)	7 (13.2)	17 (18.7)	0	
Medicare	4 (2.7)	3 (5.7)	1 (1.1)	0	
Self-pay	66 (44)	22 (41.5)	41 (45.1)	3 (50)	
Veterans affairs (VA)	3 (2)	1 (1.9)	2 (2.2)	0	
Workers comp	1 (0.7)	0	0	0	
Area of most severe injury *N* (%)					
Head/neck	47 (31.3)	11 (20.8)	34 (37.4)	2 (33.3)	0.038**
Face	10 (6.7)	2 (2.8)	8 (8.8)		0.253
Chest	23 (15.3)	12 (22.6)	10 (11)	1 (16.7)	
Abdomen and pelvis	12 (8.0%)	5 (9.4)	7 (7.7)		
Extremities	53 (35.3%)	21 (39.6)	29 (31.9)	3 (50)	
External	5 (3.3%)	2 (3.8)	3 (3.3)		

**Statistically significant at $p < 0.05$

Table 3: Overall resource utilization and cost

Resource used	*M*	*SD*	*Minimum*	*Maximum*	*M cost*
Consults	2.15	1.717	0	8	Variable
Surgeries	0.87	1.293	0	8	Variable
CTs	6.07	3.234	0	18	9499.50
Encounters	3.09	3.302	0	15	Variable
OR hours	3.19	4.958	0	35	15484.8
MRIs	0.15	0.512	0	4	307.20

Encounters, outpatient, rehab, and follow-up visits within 90 days of discharge. CT, computed tomography scan; MRI, magnetic resonance imaging; OR, operating room; M cost is per patient for each reported item

Table 4: Comparison of resource use by injury severity

	Injury severity				
Utilized resource	*Mild*	*Moderate*	*Severe*	*Highly severe*	*p-value*
Percent of total population	33.3%	28.7%	16.0%	22%	
Resources used	M (SD)		M (SD)		
OR Time	2.66 (3.73)		4.07 (6.44)		0.046
Consults	1.59 (1.1)		3.07 (2.12)		0.055
MRIs	0.05 (0.23)		0.30 (0.76)		0.002
CTs	5.74 (3.38)		6.61 (2.92)		0.049
Surgeries	0.73 (0.98)		1.09 (1.68)		0.051
Other encounters	3.65 (3.97)		2.75 (2.78)		0.053
Rate of activation of other services*	*N* (%)		*N* (%)		
PT	61.3%		75.4%		0.037
OT	50.5%		70.2%		0.009
SLT	9.7%		38.6%		<0.001

PT, physical therapy; OT, occupational therapy; SLT, speech and language therapy; ISS, Injury Severity Scale; ISS classification based on the trauma classification criteria[9]; other encounters include post discharge follow-up, outpatient clinic encounters, outpatient rehab; rate of activation of other services is for services used in the inpatient setting; *listed percentages will not add up to 100% as only those who required the services are reported in the table

Table 5: Comparison of patient outcomes by injury severity

		Injury severity			
Disposition type	*Overall*	*Mild*	*Moderate*	*Severe*	*Highly severe*
Ambulatory	78%	94%	83.7%	70.8%	51.5%
Inpatient rehabilitation	20%	–	14%	25%	24.2%
Skilled nursing facility	0.7%	–	–	–	3%
Died in hospital	5.3%	–	–	4.2%	21.2%
Transferred hospitals	2.7%	6%	2.3%	0	0
Chi-squared statistics			$\chi^2 = 44.81$ (df = 12); $p < 0.001$		

Table 6: Comparison of resource utilization

	Helmeted	*Unhelmeted*
Average ISS	*13.77*	*14.80*
% ISS greater than 16	36.0%	38.5%
Discharge disposition		
Ambulatory	73.6%	81.3%
Impatient rehabilitation	20.80%	8.7
Expired	1.9%	6.6%
Average # Days LOS	10.5	8.7
Average # Days LOS	10.5	6.3
Average # Days LOS	0.06	0.21
Average # Days LOS		
OR	4.24	2.57
Average # surgeries	1.13	0.73

Severely injured patients in our cohort had significantly greater resource use in terms of OR time, average number of surgeries, CT scans, specialty consultations, and number of follow-up encounters within 90 days of hospital discharge. As almost half of the patients in our study population had no insurance coverage, the cost of higher resource utilization may be transferred to the patient resulting in financial toxicity but ultimately will be a burden placed on the hospital system.

As expected, more severely injured patients died in the hospital when compared to moderately injured patients. It is imperative to note that this mortality rate was limited to deaths recorded in patients that were transported to our hospital after their crash and do not account for scene deaths.

Motorcyclists would benefit from stricter helmet laws in terms of morbidity, mortality, and cost. Insurance coverage, including personal injury protection, for all riders, would lessen the burden of cost falling on the trauma system. The ineffective nature of Florida's helmet law is seen in the overall poor helmet compliance rate and the lack of insurance coverage by almost half of our riders without helmets at the time of crash. A universal helmet law would save lives as nonhelmeted riders carry a greater risk of severe head and neck injuries and therefore are more likely to experience inhospital or on-scene mortality.[14]

It must also be noted that when stratifying by helmet status, the significant demographic factor difference among our population was in sex distribution. Although men made up a significantly higher proportion of both the helmeted and nonhelmeted rider groups, a higher proportion of women were found to be nonhelmeted at the time of the crash. Safety and education campaigns addressing female-specific risks are promising areas for risk mitigation.

Our study is not without limitations. Our proxy for operative resource consumption was hours spent in the OR, which has a direct monetary value. We did not account for the type of equipment used and intraoperative consulting of surgeons of other

specialties, which could potentially change the monetary amount of resource use in our population. In addition, differences between our helmeted and nonhelmeted groups in patient outcome and location of the injury may have been influenced by the survival bias, as motorcyclists brought to a trauma center due to a crash injury likely either suffered more minor injuries or had protective measures such as a helmet that allowed them to survive the initial impact. Further studies into this patient population focusing on differences in protective gear use rate, injury severity, patient outcome, and resource use with examination between riders of motorcycles and scooters are warranted.

Conclusion

Given the prevalence of motorcycle use worldwide and the large proportion of death and injury from crashes seen in this population, our research reveals trends that can help riders, physicians, and treating facilities reduce morbidity, mortality, and cost burden. Motorcyclists may not be aware of the financial risks they incur whenever they ride without adequate protective gear or adequate health insurance coverage. Even with strict life-saving helmet use, expensive and debilitating extremity injuries can occur requiring hospitalization and rehabilitation. Universal helmet policies can reduce head and neck injury rates; however, more research is needed to develop protective strategies to minimize extremity injuries.

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