

Street Bikes Versus Dirt Bikes: A Comparison of Injuries Among Motorcyclists Presenting to a Regional Trauma Center

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Background: This study sought to compare the spectrum of injuries and outcomes between off-road and on-road motorcyclists.

Methods: Demographic information, accident location, helmet use, anatomic injuries, physiologic data, length of stay, transfusions, operations, Injury Severity Scores, and determination of death were abstracted for a consecutive cohort of patients over a 5-year period.

Results: There were no significant differences between off-road motorcyclists (n = 376) and on-road motorcyclists (n = 371) in terms of helmet use, loss of consciousness, initial systolic blood pressure, initial Glasgow Coma Scale, initial Revised Trauma Score, or hand, wrist, forearm, arm, clavicle, foot, ankle, femur, pelvis, spinal, or head injuries. On-road motorcyclists were significantly more

likely, however, to require transfusions ($p < 0.025$); sustain blunt chest, abdominal, or skin trauma; or die ($p < 0.05$).

Conclusions: On-road motorcyclists are more likely to sustain blunt abdominal trauma, blunt chest trauma, skin trauma, and death than off-road motorcyclists.

Key Words: Motorcycles, Trauma, Emergency medical services.

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Since the first motorcycle was built in 1885, motorcyclists have been getting injured and killed as a result of crashes both on and off the road. In 2000, 2,862 motorcyclists were killed, and another 58,000 were injured in traffic crashes in the United States. This rate is up 15% from the fatalities reported only 1 year earlier. Per vehicle mile, motorcyclists are about 18 times more likely than passenger car occupants to die and 3 times more likely to be injured in a traffic crash.¹ New motorcycle sales have increased for the past 9 consecutive years.²

Until the 1950s, there was just one kind of motorcycle available. Over the intervening years, off-road motorcycles have evolved significantly differently from on-road motorcycles. Not only are the motorcycles themselves different, but most off-road motorcycle crashes involve different mechanisms, speeds, and terrain. Off-road and dual sport machines (capable of both on- and off-road use) now represent 27.8% of motorcycle use in the United States. Off-road motorcycle use has increased 14.8% since 1990.²

Despite the increased popularity in motorcycle use, there is very little information about how injury patterns differ between off-road and on-road motorcyclists. With this in mind, the current authors sought to review motorcycle injuries presenting to a regional trauma center.

MATERIALS AND METHODS

Study Design

This study involved a retrospective consecutive case series review of all motorcycle accident patients presenting to a regional trauma center in southern California.

Study Setting and Population

All the patients involved in motorcycle accidents and presenting to this level 1 trauma center located in the center of southern California were eligible for the study. This tertiary care center serves as the only level 1 trauma center for an area encompassing approximately 25% of California with a population exceeding 3.3 million.

Study Protocol

Motorcycle trauma patients were identified using external cause of injury codes (International Classification of Disease, revision 9 [ICD-9] E codes 810-825) for all patients seen in the emergency department or admitted to the hospital between July 1997 and July 2001. Patients were excluded if their medical record could not be located, if their medical record was incomplete, or if it could not be determined whether the accident had happened on or off the road.

A retrospective explicit chart review was conducted by a single research assistant using a standardized data abstraction tool. The abstractor was trained to review the prehospital run sheet, the emergency department record, the admission history and physical examination results, any operating room records, any intensive care unit (ICU) records, any transfusion records, the discharge summary, and any laboratory results. For each patient, the following information was abstracted: date of visit, gender, age, on-road versus off-road incident, whether the incident occurred during a sanctioned

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race, helmet use, loss of consciousness, initial systolic blood pressure, initial Glasgow Coma Score, Revised Trauma Score, length of hospital stay, whether ICU admission was required, whether an operation was performed, whether a transfusion was required, and whether the patient had died. Additionally, the following discharge diagnoses were abstracted: hand, wrist, forearm, arm, clavicle, foot, ankle, lower leg, femur, pelvic, cervical spine, thoracic spine, lumbar spine, sacral spine, other spine, head, skin, and other injuries, as well as abdominal trauma and chest trauma. An Injury Severity Score from the trauma registry of the authors' institution also was abstracted for all the patients who required admission to the hospital.

A standardized abstraction form was used, which specifically defined each of the preceding criteria. On-road motorcycle accidents were defined as those that happened "on pavement," whereas off-road accidents were defined as those that happened while the rider was not on a road or those that occurred on a nonpaved road.

The abstractor performance was monitored by the authors (J.T.G., A.C.) throughout the study. Any questions regarding data abstraction were answered on an ongoing basis during the data abstraction process. The abstractor was blinded to the study objective.

The data were analyzed to determine whether there was a difference between off-road and on-road motorcycle accidents in terms of demographics, helmet use, loss of consciousness, certain injuries by anatomic location, Injury Severity Scores, certain physiologic data, lengths of hospital stay, ICU admissions, operations performed, and deaths.

For each of the aforementioned categories, χ^2 tests were used to compare off-road with on-road motorcycle accidents. Statistical significance was established by *p* values less than 0.05. Systat (Richmond, CA) software was used for all the analyses.

This study was reviewed and approved by the institutional review board of the participating trauma center.

RESULTS

This study enrolled 751 motorcycle riders. Four riders were excluded because it could not be confirmed whether their accidents were off or on the road. The study population was divided almost equally, with 376 patients riding off-road motorcycles and 371 patients riding on-road motorcycles. Whereas both groups tended to be young males (Fig. 1), the on-road motorcyclists generally were older, less likely to be racing ($p < 0.001$), and equally likely to be wearing a helmet (Table 1). The study participants ranged in age from 4 to 83 years (mean, 29.4 years). The review showed that 2% of the motorcyclists ($n = 14$) died as a result of their injuries.

Seasonal variations were noted. Off-road motorcycle accidents predominated during the winter months, whereas on-road motorcycle accidents predominated during the summer months (Fig. 2).

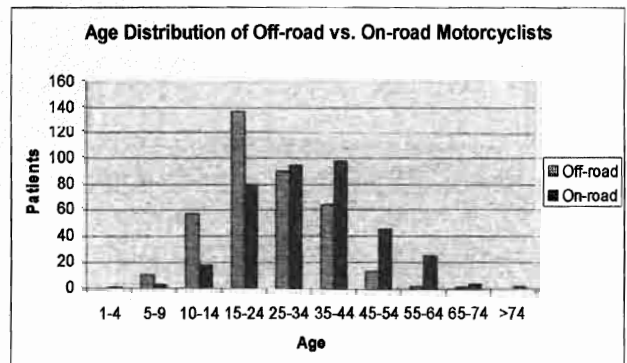


Fig. 1. Age distribution of motorcycle accident victims. Off-road motorcycle riders tended to be younger than those riding on-road motorcycles.

The physiologic characteristics of off-road and on-road motorcycle accident patients were compared using χ^2 analysis. There was no significant difference between the groups in terms of the initial systolic blood pressure, the initial Glasgow Coma Score, the Revised Trauma Score, or whether the patient lost consciousness.

The anatomic locations of actual injuries sustained also were compared between the two groups (Table 2). The findings showed that on-road motorcyclists were significantly more likely to receive a diagnosis of blunt chest trauma, blunt

Table 1 Demographic and Clinical Characteristics of Patients

	Off-Road Motorcyclists	On-Road Motorcyclists
Number	376	371
Mean age (years)	24.9	34.1
Gender—male n (%)	363 (97)	328 (88)
Racing n (%)	68 (18)	22 (6)
Helmet—yes n (%)	306 (81)	304 (82)
Helmet—no n (%)	21 (6)	34 (9)

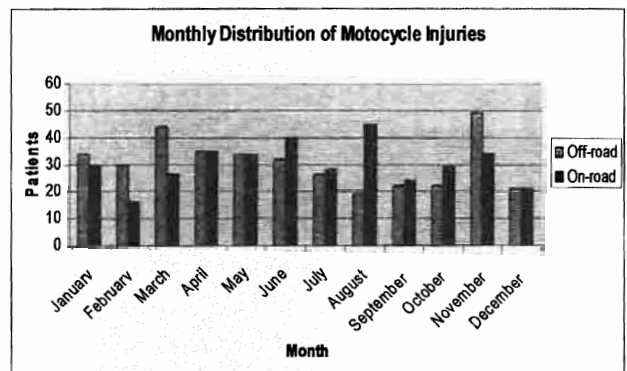


Fig. 2. Monthly distribution of motorcycle accidents. Off-road motorcycle accident rates are highest in the winter, whereas on-road motorcycle accident rates are highest in the summer.

Table 2 Injury Characteristics by Anatomic Location

	Off-Road Motorcyclists n (%)	On-Road Motorcyclists n (%)
Head	75 (20)	68 (18)
Spine	30 (8)	18 (5)
BCT	45 (12)	64 (17)
BAT	19 (5)	33 (9)
Upper extremity	67 (18)	58 (16)
Lower extremity	70 (19)	85 (23)
Skin	152 (40)	223 (60)

BCT, ●●●; BAT, ●●●.

abdominal trauma, or skin lesions. There was no statistically significant difference in hand, wrist, forearm, arm, clavicle, foot, ankle, lower leg, femur, pelvis, cervical spinal, thoracic spinal, lumbar spinal, sacral spinal, or head injuries between the two groups.

Although the Injury Severity Scores tended to be higher in the on-road motorcyclist group, the difference did not reach statistical significance. Both groups of motorcyclists were equally likely to be admitted to the hospital, require ICU admission, or require surgery. However, on-road motorcyclists were significantly more likely to require blood transfusions ($p < 0.025$) and die ($p < 0.05$).

DISCUSSION

In the past decade, there has been a dramatic increase in both the number of motorcycle sales² and the number of motorcycle accident-related fatalities in the United States.³ The current study was similar to previous studies showing that most motorcycle injuries and fatalities³ are among young to middle-age men who tend to be in their working prime. As a result, these accidents pose a tremendous burden to individuals and society in terms of suffering, disability, death, and costs.

The question whether on-road or off-road motorcycles are safer to ride is difficult to answer fully with this study. Intuitively, it may be suspected that on-road motorcyclists are at greater risk of injury or death because of the often higher speeds and generally increased traffic involved in on-road motorcycle riding. Although the mortality rate for on-road motorcyclists was significantly higher than for off-road motorcyclists presenting to the authors' facility, this number may have been affected significantly by referral bias. In addition, this study and trauma registries generally are inaccurate with regard to the denominator. They contain little or no information about patients with minor injuries or no injuries, and are best able to give only the numerator for those with injuries requiring treatment and those who died. The correct denominator of those at risk, however, is made up entirely of accidents.⁴

Previously published reports have suggested an incidence of 1% to 21% for spinal injury in motorcycle crashes.^{5,6} The current results are similar (8% for on-road and 5% for off-road accidents). The incidence of head injuries in the current study (18% for on-road and 20% for off-road

accidents) is slightly higher than in previous studies,^{5,6} whereas the current incidence of lower extremity injuries is considerably lower (23% for on-road and 19% for off-road accidents) than at least one prior study⁶ that reported an incidence of 46%. The incidence of upper extremity injuries was similar between these studies.

Some have argued that motorcycle safety policy is fundamentally flawed because it is built on "safer crashing," not "safer riding." Unlike passengers in most vehicles, motorcyclists are more vulnerable because of their exposed riding position. Whereas passenger vehicles are able to dissipate much of the energy during a crash, thus preventing the driver from full exposure to the impact forces, motorcyclists tend to be much more exposed to these forces. Although certain safety equipment has been demonstrated to decrease injuries and death, it should be obvious that the best way to decrease injuries and deaths is to prevent the accident from happening in the first place. The authors believe individuals should be urging the federal government and other organizations to embrace accident prevention rather than injury minimization during a crash.

Whereas motorcycle racers in one study were found to have 15 times the injury rate and 87 times the fatality rate of recreational riders,⁷ the current study did not demonstrate injury and fatality rates of on-road and off-road motorcycle racers significantly different from those of on-road and off-road nonracers.

During the past decade, environmental groups have successfully closed many off-road motorcycle riding areas at the same time that the number of motorcycles sold has significantly increased. If off-road motorcycle riding is safer partly because the incidence of collision with other vehicles has decreased, it will be interesting to see how these closures will affect the injury and fatality rates for off-road motorcyclists. Data regarding trends in the number of multiple-vehicle off-road motorcycle accidents should be examined to determine the effect of off-road riding area closures on safety.

This study had several important limitations. The data included only information on acutely and seriously injured patients treated at a single level 1 trauma center. Excluded were the minimally injured, those who never seek care (or refuse care), those treated and released by prehospital personnel, and those who were dead at the scene of the accident. In addition, the weather in southern California tends to be dry and warm, so these results may not be applicable to other areas.

CONCLUSION

Although both off-road and on-road motorcyclists had mostly similar injuries, the chances of having significant blunt abdominal trauma, significant blunt chest trauma, significant skin trauma, or fatality were significantly greater for on-road than for off-road motorcyclists.

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Book Review

Posttraumatic Stress Disorder in Children and Adolescents Handbook Raul L. Silva, MD W.W. Norton & Company, New York, 371 pp., \$22.95

Unfortunately, the world our children live in has the potential for many forms of trauma; the reader only needs to watch the nightly news to realize that many children face severe challenges to their own personal safety and that of their loved ones. Dr. Silva's thoughtful and timely review of trauma and posttraumatic stress disorder (PTSD) will be useful to any practitioner who sees traumatized children. The contributors to this work have a wealth of clinical and research expertise. As noted by Dr. Silva in the Preface to this book, the proximity of these authors to the recent terrorist attacks on New York City delayed the completion of this work, but their experience is relevant to issues many clinicians are facing.

This book highlights that childhood is not a static event and therefore the symptomatology will vary on the basis of the person and characteristics of the exposure. Given the number of different factors that need to be considered, the task of caring for these children can seem overwhelming. This book therefore provides a useful summary of the key aspects a clinician must consider.

The strength of this work is the breadth of topics that are covered. This book covers types of trauma, the neurologic and physiologic underpinnings, legal aspects, and treatment. Experts in the field should find this volume to be a first-rate review, whereas newcomers to this area will find this book to be an excellent introduction. A major asset of this work is that each chapter can function as a stand-alone reference for a reader. This format results in some redundancy for those reading the entire book but provides a reader with comprehensive coverage of select topics of interest.

For clinicians unfamiliar with the diagnoses or seeking a brief review, I highly recommend Chapters 1, 7, and 10 through 14. These should be considered "core chapters" that provide an overview of the epidemiology, presentation, clinical course, and treatment of the disorder. Chapter 1 is a superb review of the many ways children in today's world can be traumatized (i.e., community violence, crime, abuse, natural disasters, war, accidents). This chapter alerts clinicians who work with children to the potential of psychological sequelae from a variety of different sources. Key points of the other chapters include the diagnostic criteria, diagnostic tools, differential diagnoses (especially the similarities between anxiety and depression), and the differences between adult and child presentations. In addition, the chapter regarding the clinical course of the disorder has a useful table noting key studies that examined the relationship of exposure to the clinical presentation. The strength of the chapter regarding treatment is the description of the basic principles of psychotherapy as it pertains to traumatized patients. The reference list will be helpful to those who want greater expertise in this area. The review of psychopharmacologic trials is a useful starting point. As the authors note, empirical evidence in this area is sorely lacking; therefore, this chapter does not cover many of the current pharmacologic options used by clinicians struggling with the complexities of patients with this disorder (symptom severity, comorbid diagnoses, atypical presentation). A number of recent reviews are available for readers with a greater interest in the pharmacologic treatment of PTSD.

I highly commend the editor for including the chapter on legal aspects related to this disorder in children and adolescents. This chapter reviews useful topics that are rarely covered in the scientific literature such as litigation, forensic evaluation, and court proceedings.

Two other commendable chapters are Chapters 5 and 6 on the neurobiology, causes, and pathogenesis of PTSD. There are clear, very well written chapters that review neurotransmitter systems (especially catecholamines), neuroendocrine systems (in particular, the hypothalamic-pituitary-adrenal axis), neuroanatomy, and physiology associated with exposure to trauma.

The remaining chapters are focused on special issues related to PTSD. These topics will be useful to readers with specific interests such as resiliency, vulnerability, risk factors, gender issues, intergenerational links, and the effects of war. In summary, this book is a superb resource to anyone who works with traumatized children.

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