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The hazards of off-road motor sports: Are four wheels better than two?

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ABSTRACT

Background: Off-road motorsports are an increasing popular activity, yet the relative safety profile of all-terrain vehicles (ATV) to off-road motorcycles (ORMC) has not been compared.
Study design: A retrospective review of the 2002–2006 US National Trauma Data Bank of ATV and ORMC crash victims. Patients were described according to demographic (age, sex, race and ethnicity, insurance status) and injury characteristics (Injury Severity Score, hypotension, motor component of the Glasgow Coma Score, presence of a severe head or extremity injury) known to affect trauma outcomes. Logistic regression evaluated the independent effect of an ATV vehicle on mortality, intensive care unit (ICU) admission, and placement on a ventilator relative to ORMC. The anatomic distribution of severe injuries was compared between survivors and decedents within each vehicle type.
Results: A total of 34,457 patients met inclusion criteria, of whom, 24,582 were ATV patients and 9875 were ORMC patients. ATV patients had 51% higher risk-adjusted odds of death (OR 1.51; 95% CI 1.03–2.20), 55% higher risk-adjusted odds of being admitted to an ICU (OR 1.55; 95% CI 1.42–1.70), and 42% higher risk-adjusted odds of being placed on a ventilator (OR 1.42, 95% CI 1.17–1.72) compared to ORMC crash victims. Decedents in both vehicle types were more likely to suffer severe head, thoracic, and abdominal injuries relative to their surviving counterparts.
Conclusion: For injured riders, ATVs are associated with increased mortality and higher resource utilisation compared to ORMCs. Both groups suffer distinct anatomic injuries, suggesting the need for focused areas of injury prevention planning and research.

Introduction

Off-road motor sports comprised an estimated 13.5 billion dollar market in the United States in 2004 [1]. ATVs, in particular, have enjoyed growing popularity since their initial commercial availability in the early 1970s [1]. Sales of ATVs have steadily increased with approximately 311,000 units sold in 2009 [2]. However, there have been significant safety concerns over the platform. High rates of vehicle rollovers and mortality among riders prompted the manufacturers to enter into a 10-year US federal consent decree in 1988. The decree barred manufacturers from selling three-wheeled versions and required them to both affix appropriate safety warnings to all ATVs as well as offer free rider training to purchasers of ATVs [3]. As their popularity as both a recreational and utility vehicle has increased, so too has the number of ATV-related injuries presenting to the Emergency Department (ED). ED visits for ATV-related injuries increased from 92,200 in 2000 to 150,900 in 2007 [4]. Evaluation of the US Healthcare Cost and Utilization Project, Nationwide Inpatient Sample showed a 90% increase in hospital admission rates from 2000 to 2004 [5].

Numerous studies have demonstrated that ATV crash victims often suffer severe injuries. Balthrop et al. reported that almost half of all patients injured while riding ATVs had fractures or dislocations [6]. Injured ATV riders are also at risk for increased hospitalisations [7], cervical and thoracic fractures [8], renal contusions and lacerations [9,10], neurological injury for paediatric riders [11], and maxillofacial injuries compared to other motorised vehicles [12].

Similar to ATVs, interest in ORMCs has grown, especially among young riders [13]. Few studies have specifically addressed ORMC

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injuries, but a review of injured ORMC riders from a California hospital reported high rates of extremity and closed head trauma [14,15]. The paediatric population is especially vulnerable to injuries from ORMCs [14,15].

Little work has been done to compare the relative safety profiles of off-road vehicles. In a single centre, retrospective review of ATV injuries to on-road motorcycles in Puerto Rico, Acosta et al. found minimal differences between the two vehicle platforms; Brown et al. compared ATV injuries to bicycle injuries [16,17]. These comparisons are important in contextualising ATV injuries relative to those suffered while riding other vehicles, but significant differences exist in safety behaviour and riding conditions between ATV use and on-road vehicles which complicate their juxtaposition. Furthermore, those comparisons also do not reflect the real life choice that consumers may make when participating in off-road recreational activities, such as choosing between an ATV and an off-road motorcycle (ORMC). Given the similar terrain and high risk for significant injury, the objective of this study was to use a national, trauma specific database to compare the mortality, morbidity, and injury patterns of ATV users to ORMC users.

Methods

The study was conducted as a retrospective analysis of the 2002–2006 US National Trauma Data Bank (NTDB), which is maintained by the American College of Surgeons (Chicago, IL, USA). It is the largest repository of trauma data in the United States, with over 750 participating trauma centres and hospitals reporting data on 1.86 million patients. Since helmet use has been previously shown to be protective for mortality, hospitals that did not report safety data were excluded from analysis (Fig. 1) [18,19].

Trauma patients who were involved in either an ATV or ORMC crash were identified according to International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM) external cause of injury codes (Ecode) 821.0–821.9. This corresponds to injuries of the driver, passenger, or another person injured in an off-road vehicle crash. Ecodes E821.0, E821.1, E821.8, and E821.9 were used to define individuals in an ATV, while Ecodes E821.2 and E821.3 were used to identify passengers, occupants, or riders of ORMCs. E821.4, E21.5, E821.6, and E821.7 were excluded because they referred to injuries involving streetcars, animal-drawn vehicles, non-motorised vehicles, or pedestrians. Although a small number of three-wheel ATVs purchased prior to the 1988 consent decree may still be in use, the Ecodes do not distinguish between three and four-wheeled ATV crashes.

The primary outcome for this analysis was mortality. Secondary outcomes included: admission to an intensive care unit (ICU) and placement on a ventilator as defined in the NTDB. Patients of ATV and ORMC crashes were compared according to patient and injury characteristics. Demographic information included age, sex, race/ethnicity, insurance status, geographical region, and safety helmet use at the time of injury. Preliminary data analysis showed that ORMC and ATV ridership was distributed across both the adult and paediatric population, so patients were categorised according to age: 0–12, 13–16, 17–23, 24–30, 31–40, 41–50, and >50 years old. Insurance status has been associated with outcomes in trauma patients, so patients were categorised according to one of four groups: private insurance, public insurance, uninsured, or other as previously described [20]. Descriptive analysis demonstrated geographic variation in mortality and was, therefore, included as a potential confounder.

The degree of injury was characterised by established measures known to account for anatomic injury severity and physiologic status. Patients were categorised according to one of four groups based on Injury Severity Score (ISS)–minor (ISS 0–8), moderate (ISS 9–15), major (ISS 16–24), or severely injured (ISS $\geq$ 25) – and whether the injury was a penetrating or blunt injury [21]. Physiologic status was assessed by the motor component of the Glasgow Coma Score (ED GCSm) and presence of hypotension on presentation to the Emergency Department. Since the study included a paediatric population, shock was defined as follows: systolic blood pressure (SBP) < 74 mmHg for ages 0–2 years; SBP < 78 mmHg for ages 2–4 years; SBP < 82 mmHg for ages 4–6 years; SBP < 86 mmHg for ages 6–8 years; and SBP < 90 mmHg for ages $\geq$8 years. The presence of a severe injury by anatomic location (head, spine, thorax, abdomen, and extremity) was measured using hospital-provided Abbreviated Injury Scale (AIS) and defined as a score $\geq$3 [22].

One-way analysis of variance (ANOVA) and Chi-square tests were used to evaluate mean and proportional differences, respectively, between ATV and ORMC patients for patient and injury characteristics and the outcomes of mortality, admission to an ICU, and placement on a ventilator. Multivariable logistic regression was done to examine the association between off-road vehicle type (ATV versus ORMC) and the outcomes listed above, controlling for patient and injury characteristics (age, sex, race/ethnicity, insurance status, geographic region, ISS, ED GCSm, penetrating injury, a severe head and/or extremity injury, shock, helmet use, and year of admission). Odds ratios (OR) and 95% confidence intervals (95% CI) were reported with statistical significance at $p < 0.05$. Sensitivity analysis for missing data was done through multiple imputation. Five iterations of imputation were performed for all the above covariates in the model and then averaged to produce a final imputed dataset upon which all analyses were repeated. All analyses were performed using Stata version 10 (Stata Corp., College Station, TX, USA).

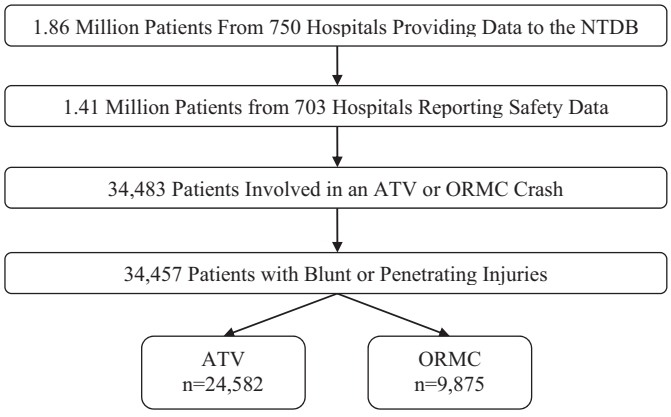

Fig. 1. Patient selection.

Results

Of the 750 participating NTDB hospitals, 703 routinely reported protective device data on 1.41 million patients, including 34,457 patients who met the inclusion criteria as either ORMC (n = 9875, 28.7%) or ATV (n = 24,582, 71.3%) patients (Fig. 1). The mean age for the entire population was 26.8 years, and 81.8% of the cohort was men (Table 1). Insurance status was uniform between ORMC and ATV patients, with the majority of patients having either public or private insurance. Overall, off-road motor crashes for the entire cohort occurred most frequently in the South (35.1%), but there was variation by vehicle type with more ORMC crashes occurring in the West (39.6%), than in other regions.

Table 2 shows the injury characteristics for ATV and ORMC patients. No significant unadjusted differences were observed in either ED GCSm or in the proportion of ATV patients presenting with minor injuries (ISS < 9). However, a larger proportion of ATV patients had a major (ISS 16–24) or severe injury (ISS $\geq$ 25) when