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Comparative analysis of all-terrain vehicles, motorcycle, and motor vehicle cars related trauma in a rural border community of the United States.

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Abstract

Introduction. There is widespread use of all-terrain vehicles (ATV) in the United States for both work-related and recreational activities. ATVs sale and use remain loosely regulated, and regulations vary from state to state. In this study, we aimed to test if ATV use is a common cause of severe injuries in the Rio Grande Valley (southernmost border region of the U.S.), considering the somewhat rural nature of the area. **Methods.** We retrospectively analyzed ATVs, motorcycle (MOTO) and motor vehicle car (MVC) injuries entered into the hospital trauma registry from 01/01/2015 to 08/31/2020. Results revealed that ATV-related injuries in our region follow national trends with increased occurrence among children (younger than 16 yr. age) and young males compared to MOTO and MVC injuries. **Results.** Victims of ATV-related injuries are more likely to have a higher injury severity score and open fractures. They are also more likely to have more extended hospitalization, higher healthcare-related costs, and less likely to have insurance coverage. **Discussion.** Young victims are very likely to suffer sequela and long-term disability due to the severity of ATV-related injuries. This is a serious nationwide problem, and the data confirms that our region is equally affected, if not more. Public awareness campaigns to educate our population, especially our youth, about unsafe ATVs' dangers are highly needed.

Keywords: rural, children, protective equipment, unsafe, open fracture

Strengths and limitations of this study

- The likelihood of an open fracture in an ATV injury is disproportionately large compared to motorcycle and car injuries in our region, yet mortality is minimal compared to national averages.

- Motorcycles and ATV injuries have a similar hospital total cost, but ATV patients are much more likely to report Medicaid as the main payer.
- In the southernmost region of the United States, there is no use of protective equipment while using ATVs.
- This is a single center study that serves as initial data for our region, but multi center trials could be designed as well as randomized trials.

Introduction

All-terrain vehicles (ATVs) are three- or four-wheeled motorized vehicles with large soft tires, a relatively high center of gravity, and handlebars like a bike. They are typically designed for a single operator to straddle the vehicle's body and are primarily used for off-road activities [1]. ATVs were first developed in the 1960s as a farm vehicle and later introduced in the United States in the early 70s [2,3]. Early generations ATVs had a small 7-horsepower/89-cc engine and weighed less than 200 lb. Modern ATVs have engines with over 600-cc/50-hp, weigh over 600 lb., and reach a speed above 100 mph. ATVs are classified as lightweight two-wheel-drive sport vehicles that accelerate quickly and utility vehicles, which are typically larger four-wheel-drive vehicles designed for off-road use. Recreational use of ATVs increased dramatically shortly after their introduction. By the year 2000, nearly four million vehicles were sold in the U.S.A. The U.S. Consumer Product Safety Commission (CPSC) estimates that 10.7 million four-wheeled ATVs were used in the U.S.A. in 2012 [4,5].

In 1988 the CPSC imposed a 10-year ban on the sale of three-wheeled vehicles due to the dramatic injury rate. During that ban, four-wheeled vehicle were further developed [6]. Since the ban expired in 1998, there has been a dramatic increase in the production of more powerful

ATVs with a corresponding rise in ATV-related injuries, especially among children and young adults [7]. In 2009 the Consumer Product Safety Improvement Act was passed to ban lead from products designed for children under the age of 12 years. The act limited the availability of smaller ATVs designed for and marketed to children as entry-level vehicles. The CPSC later acknowledged that the ban on youth ATVs might have resulted in children under 12 years riding larger, more powerful adult-sized vehicles [8].

The 10-year ban was combined with a legally binding 10-year consent decree with the ATV industry to reduce injury and death. After its expiration, it became a voluntary non-enforceable agreement that limited the sale of adult-sized vehicles to children and increased the number of rider safety awareness and education programs. Despite that, ATVs' sale and use remain loosely regulated, and regulations vary from state to state. For example, in Louisiana, children under the age of 12 may operate ATVs with parental supervision, and those between the ages of 12 and 16 may ride without adult supervision with no safety equipment required. In Texas, age-related restrictions for ATVs use and safety equipment laws are only mandatory on public land. The District of Columbia has no regulatory statutes. Only 21 states have helmet and safety equipment regulations [9]. As a result, the CPSC and individual states have failed to interrupt the pattern of increasing injury and death caused by ATVs use. The annual cost of ATVs-related injuries was estimated at over $6.5 billion in 2003 [10].

According to the CPSC, close to 100,000 ATV-related injuries were treated in emergency departments in 2013 in the U.S. [4]; most injuries resulting orthopedic injuries [11]. Risk factors for such injuries include young and inexperienced riders, male gender, intoxication, lack of helmets and protective equipment, and operating on the road [12]. Children under the age of 16 are at a notably higher risk for ATV-related injuries. Although 15% of ATV riders are children, it is estimated that children account for 27% of ATV-related injuries and 28% of ATV-related deaths [5,13,14]. Some estimates put that number even higher, up to 50% of ATV-related injuries. The majority of injured children (76%) are males. From 1997 to 2006, there was a 140% increase in ATV-related injuries among children and a 368% increase in spinal injuries. Children are more at risk for sustaining ATV-related injuries and death due to decreased emotional maturity, motor skill, depth perception, and experience. Children are also smaller and have lower body mass than adults, which may contribute to rollovers [15].

The southernmost region of the U.S. is largely rural with a strong agricultural economy. In this region, commonly known as the Rio Grande Valley, ATVs are frequently used for both work and recreational use. However, local data (besides limited state statistics) is non-existent. In light of previous research in the field, we hypothesize that ATV use is a common cause of severe injuries in the Rio Grande Valley, taking into consideration the somewhat rural nature of the region. We also hypothesize that ATV-related injuries are more common among children and young adults in line with national studies. We also believe that ATV-related injuries are often severe and can result in significant morbidity and mortality, longer hospitalization, and greater healthcare cost than other motorized vehicles such as motorcycles (MOTO) and motor vehicle cars (MVC) in our trauma center. We will also examine whether ATV-related injury victims are more likely to be uninsured and less likely to use protective equipment compared to other vehicles, given the lower regulations that exist for ATVs.

Methods

Design and setting

This is a retrospective analysis of ATVs, MOTO, and MVC injuries entered into the hospital trauma registry from January 1, 2015, to August 31, 2020. The hospital is a certified Level 2 Trauma Hospital (functioning as Level 1) in the Rio Grande Valley. All data was collected de-identified for which the study received exempt Institutional Review Board approval conforming to the U.S. Federal Policy for the Protection of Humans Subjects. The hospital trauma registry contains information extracted from the patient's medical record and is used to improve quality and trauma level certification by the American College of Surgeons. All presented data involved standard of care, and no intervention took place. The second author has unlimited access to generate reports from the trauma registry using the software DI report Writer (DI Data Management System).

Patient and public involvement

This is a fully de-identified retrospective research study for which patient identity was not known. Patients were not involved in the design, conduct of the research, or choice of outcome measures. This study did not involve recruitment. Once the manuscript has been published, dissemination of the results will be promoted at the orthopedic and rehabilitation clinics at the hospital by members of the treatment teams with the main goal of increasing safety awareness when using ATVs.

Data source and Participants

The criteria for including a patient in the trauma registry follows the algorithm developed by the Committee on Trauma from the American College of Surgeons as published in the freely available National Trauma Data Standards [16]. Male and female patients of all ages entered into the trauma registry within the study dates were included. To avoid any selection bias, we did not exclude any of the patient's records.

Variables

The trauma registry divides the data elements into ten broad categories of information: patients' demographic, injury, pre-hospital, emergency department, hospital procedures, pre-existing conditions, diagnosis, hospital events, outcomes, and financial information. The registry was queried for three different searches, one for each of the mechanisms of injury: ATV, MOTO, and MVC. Each query included the same variables for each patient as follows: age, sex, ethnicity, body mass index (BMI), presence of open fracture, injury severity score (ISS), hospital length of stay, number of days in the intensive care unit, number of days in the step-down unit, post-hospital disposition (including mortality), type of protective equipment being used at the time of injury, type of payer, and total charges during the hospital stay.

Statistical Methods

Variables were summarized using descriptive statistics: frequencies and column percentages were used to summarize categorical variables, while means and standard deviations were used for continuous variables. Continuous variables were tested for normality using the Shapiro-Wilk goodness-of-fit test and compared using a One-way-ANOVA followed by a Tukey post-hoc analysis for differences between groups. Chi-square or Fisher exact tests were used for categorical variables. Odds ratios were used to quantify the risk of injury between types of vehicles and injuries in individuals younger than 16 years of age. The statistical analyses were two-sided and conducted using JMP 15.0 (SAS Institute, Inc, Carry, NC, USA). The significance was set at $p < 0.05$.

Results

Participants and demographic characteristics

The trauma registry queries returned a sample of 3942 patients' records, of which 3626 were MVC, 200 were MOTO, and 116 were ATVs injuries. The sample was divided across years in the following manner: 390 records from 2015, 882 records from 2016, 787 records from 2017, 730 records from 2018, 793 records from 2019, and 360 records from 2020. **Table 1** describes the demographic variables for the patient population. The percentage of patients younger than 16 years showing ATV injuries was three times higher than in MVC injuries and about eight times higher than the MOTO injuries (X^2= 59.51, d.f.=2, p< .0001). Patients presenting with ATV injuries were on average ten years younger than the patients with MVC or MOTO injuries ($F_{(2,3939)}$= 21.82, p< .0001). The odds of patients younger than 16 years of age sustaining an ATV injury are shown in **Figure 1A** clearly demonstrating an increased likelihood for injuries in a younger population for ATVs compared to MVC and MOTO injuries. It is deducible that the younger age group in ATV injuries corresponded to a significantly lower patient's BMI compared to patients in the MVC and MOTO groups ($F_{(2,3821)}$= 3.94, p< .05). Males predominated the traumatic injuries in MOTO and ATV but not for MVC injuries (X^2= 117.30, d.f.=2, p< .0001). The self-reported ethnicity matches that of the geographical region, with approximately 90% of the injuries observed in Hispanic/Latinos. Fortunately, mortality in the sample was low, with less than 1% in MVC injuries and none reported for MOTO or ATV.

Table 1: Demographic variables for patients with traumatic injuries occurring when using motorcycle, motor vehicle cars (MVC) and all-terrain vehicles (ATV).

Variables	MVC	MOTO	ATV	p value*	Differences

No. of patients	3626	200	116		
No. of patients ≤ 16 (% of total)	455 (12.55)	14 (7.0)	46 (39.65)	**<.0001**	MVC >MOTO, ATV >MVC & MOTO
Age, mean (SD)	32.98 (19.28)	33.56 (15.37)	21.22 (13.98)	**<.0001**	MOTO >ATV, MVC >ATV
BMI, mean (SD)	29.88 (14.76)	29.43 (10.99)	26.07 (8.03)	**.0194**	MVC >ATV
Sex, Males n (%)	1671 (46.08)	164 (82.00)	75 (64.66)	**<.0001**	MOTO >ATV & MVC, ATV >MVC
Ethnicity, Hispanic or Latino, n (%)	3398 (93.71)	177 (88.50)	114 (98.28)	**.0098**	MVC >MOTO, ATV >MVC & MOTO
Mortality, n (%)	29 (0.80)	0 (0)	0 (0)	N/A	N/A

*Calculated using one way ANOVA for continuous variables and Chi-square for categorical variables.

<u>Main outcomes</u>

To compare the severity of the injuries, we used the ISS and the presentation of open fractures for each type of vehicle. The highest percentage of open fracture presentation was reported for ATV injuries, significantly different from MVC and MOTO injuries (**Table 2**; X^2= 26.15, d.f.=2, p< .0001). To further explore the likelihood of open fractures in ATV injuries, we calculated the odds ratio compared to MVCs and MOTOs. The odds of sustaining an open fracture while riding an ATV is 9.4 times higher (95% CI: 3.8 to 21.8) when compared to an MVC and 1.8 times higher when compared to a MOTO (95% CI: 0.6 to 4.7; **Figure 1B**). Parallel to this, the ISS for ATV and MOTO injuries is on average 1.7 points higher than for MVC injuries ($F_{(2,3085)}$= 10.34, p< .0001). This severity translates into an increased total hospital length of stay, which was the highest for MOTO and ATV injuries ($F_{(2,3941)}$= 13.95, p< .0001, Table 2). Consequently, the total cost of healthcare (total charges-Table 2) is similar for MOTO and ATV injuries, showing an expense of over 10,000 dollars spent when compared to MVC injuries ($F_{(2,3904)}$= 7.54, p< .001). Since healthcare cost could represent a significant financial burden, we examined the type of health insurance reported by the patient at the time of injury. The percentage of patients that reported no health insurance was very similar across all types of vehicle injuries: 36.1% for MVC, 34.5% for MOTO, and 36.2% for ATV. Commercial health insurances (e.g., Blue Cross) were the second-highest method of payment reported by patients, closely followed by Medicaid insurance. In fact, Medicaid was reported by 18.8% of the patients with MVC injuries, 11.5% of patients with MOTO injuries, and 29.3% of ATV injuries (X^2= 68.58, d.f.=22, p< .0001). The likelihood that a patient involved in an ATV injury will present to the emergency room with Medicaid as health insurance is illustrated in **Figure 1C**. It is appreciated that patients with ATV injuries will be three times more likely to be insured by Medicaid than patients with MOTO injuries. The total amount of time spent in the ICU or the Step Down units was not different between groups. Yet, patients with ATV injuries spent twice as much time in the ICU as compared to patients with MVC injuries.

Table 2: Clinical outcomes variables for patients with traumatic injuries occurring when using motorcycle (MOTO), motor vehicle cars (MVC) and all-terrain vehicles (ATV).

Variables, mean (SD)	MVC	MOTO	ATV	p	Differences

				value*	
Open fracture, n (%)	24 (0.66)	7 (3.50)	7 (6.03)	**<.0001**	ATV > MOTO & MVC
ISS, mean (SD)	3.73 (6.70)	5.68 (6.37)	5.31 (5.35)	**<.0001**	MOTO & ATV > MVC
LOS in days, mean (SD)	0.99 (3.56)	2.19 (4.23)	3.56 (2.00)	**<.0001**	MOTO & ATV> MVC
Days in the ICU, mean (SD)	0.35 (2.35)	0.55 (2.88)	0.72 (2.87)	0.136	NS
Days in the Step Down Unit, mean (SD)	0.04 (0.45)	0.09 (0.63)	0.07 (0.44)	0.477	NS
Total charges in dollars, mean (SD)	21,630 (53,301)	34,860 (53,429)	31,757 (58,087)	**.0005**	MOTO > MVC

We compared the use of any protective gear, as relevant to the type of vehicle: helmets and protective clothing for MOTO or ATV, and car seat and seat belts for MVC (**Table 3**). The percent of individuals not using protective equipment is six times higher for ATV as compared to MVCs and two times higher than MOTO injuries (X^2= 444.16, d.f.=4, p< .0001). The most frequent protective devices used were seatbelts for MVC and helmets for MOTO and ATV. The likelihood of using any type of protective equipment/device while sustaining an injury and it revealed that the use of protective devices for ATV injuries is very close to zero, as compared to MVC and MOTO (**Figure 1D**), highlighting the engagement in risky behaviors while using ATVs.

Table 3: Use of relevant protective equipment for patients with traumatic injuries occurring when using motor vehicle cars (MVC), motorcycle (MOTO), and all-terrain vehicles (ATV).

Equipment, n (%)	MVC	MOTO	ATV
Helmet		82 (46.00)	4 (3.45)
Helmet & protective clothing		15 (7.50)	0 (0)

Protective clothing		5 (2.50)	0 (0)
Car seat/Booster seat	143 (3.94)		
Seatbelt (Any type)	2850 (78.60)		
None	546 (15.06)	96 (48.00)	107 (92.24)
Unknown	87 (2.40)	2 (1.00)	5 (4.31)

Discussion

ATV-related injuries continue to be a significant cause of injuries among children and young adults. Even though ATVs are powerful machines, they are poorly regulated, and operators, especially children and young adults frequently treat them as toys. Our study showed that ATV-related injuries are more common among children and young males within the Rio Grande Valley region. Victims of ATV-related injuries were more likely to have a higher injury severity score and open fractures, longer hospitalization, higher healthcare-related costs, and less likely to have insurance coverage.

Farming terrain frequently requires the use of ATV vehicles for fast and efficient transportation. The increased likelihood of ATV ownership in the area also represents increased accessibility to children under 16 years. Yet, anecdotal evidence from clinicians in the area suggests that the injuries observed are mostly related to recreational activities instead of direct work-related use on farms. The problem of ATV use by minors is compounded by the fact that 98% of the land in Texas is privately owned [17]. This renders regulation of ATV use by children on private property a challenge to authorities with limited access for police and emergency medical services.

An unpredicted finding was the increased likelihood of reporting Medicaid as the primary insurance for ATV injuries. The most likely explanation for this may be due to stricter regulations and requirements for insurance coverage while operating motorcycles and cars resulting in healthcare costs being covered by the commercial insurance injury policy. Only four states have language-related to ATV insurance requirements: New Jersey, New York, and Pennsylvania require liability insurance, while Nebraska only requires insurance if the vehicle is going to be operated on a highway [18]. The requirement for insurance to operate motorcycles compared to ATVs represents an increased ownership cost. Consequently, it limits motorcycle ownership to people who have the economic means to sustain its ownership and operation. While the type of health insurance is not a direct measure of socioeconomic status, Medicaid is frequently used by families who cannot afford private insurances. For example, In Texas, the maximum monthly income for Medicaid eligibility for children ages 6 -18 was $2,235 [19]. Therefore, the burden of ATV injuries in our region is dual: an increased cost to publicly funded health insurances and possibly hospitals and a capital loss for the owner by losing a possibly used vehicle for work. We propose nationwide requirements for ATV insurance regardless of its use that include some injury coverage. This is due to its similarities with motorcycle injuries and the significant financial burden it can generate in medical costs.

The most dangerous ATV injuries involve vehicle rollovers. Unlike motor vehicles, ATVs are similar to motorcycles regarding the lack of shell protection to its operator/passenger. This increases the likelihood of sustaining more severe injuries and soft tissue damage even with low-speed injuries. Hence it is no surprise that open fractures in ATV injuries was high in our cohort. The time spent in the ICU for patients with ATV injuries compared to MOTO and MVCs was not significantly different suggesting differences in the body regions affected. For example, high-speed MVC injuries may lead to closed head and internal organ injuries. In contrast, ATV injuries might be mostly related to external anatomy and limbs, with fractures being the most common type of injury [20]. Nevertheless, most open fractures and soft tissue injuries require multiple interventions to lower the risk of infection rate and may require several surgical specialties such as plastic surgeons, and vascular surgeons. Therefore, open fractures potentially result in increased LOS and higher medical costs overall.

The long-term sequelae and disability from the injuries may affect their choice of care. For example, rehabilitation practices for traumatic brain injury, spine injuries, and fractures depend on the injury severity and the impact on daily life activities [21,22]. Taken together, an increase in supervision from parents when minors use ATVs and heightened awareness of the benefits of protective equipment while riding are highly recommended.

Limitations

All retrospective studies have intrinsic limitations due to their design; nevertheless, they provide a structure for the design of interventions and larger clinical studies. One of the largest limitations in our data was the sample size for ATV injuries. Our institution is the only acting Trauma Level 1 center in the region. Hence, we presume a large catchment of injuries in the area. However, the mortality observed in our cohort is not following the previously reported national averages [23], with the most reasonable explanation for this being a small sample size. On the other hand, we hypothesize that emergency medical personnel might be already familiar with ATV injuries in our region, thus providing early interventions in severe cases. This still needs to be tested compared to the other areas of the nation with a similar farming economy. We did not account for spinal cord injuries or traumatic brain injuries, as it was not the goal of the current study. However, we recognize the vast data in this area since these types of injuries are likely to create long-term disabilities.

Conclusions

Considering the severity of ATV-related injuries, young victims are very likely to suffer sequela and long-term disability. This is a serious nationwide problem, and our data confirm that our region is equally affected, if not more. We call for a public awareness campaign to educate our population, especially our youth, about the dangers of unsafe operation of ATVs. The public awareness campaign must highlight the vulnerability of young small riders and the importance of protective equipment. There are still 19 states with no laws requiring the riders of ATVs to wear helmets, while 22 states still do not have the minimum age requirement for drivers [24]. We call on ATV manufacturers to equip all ATVs with seatbelts and anti-roll bars to minimize the risk of rollover-related injuries. Our data, combined with similar data from around the nation adds to the need of imposing stricter regulations on the ATV industry.

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Competing interest: Dr. Elzaim is employed by the Renaissance Medical Foundation, the main group that provides clinical services to DHR Health. Dr. Torres-Reveron has nothing to declare.

Ethics approval statements: Patient consent for publication was not required as all data used was de-identified. Ethics approval: This study received approval under the exempt category by the DHR Health Institute for Research and Development Institutional Review Board (protocol number 1574841-2 approved on 08/18/2020).

Contribution's statement: HSE conceptualized the study, wrote the first manuscript draft, and supervised the overall project. ATR extracted and analyzed the data, wrote methods and results. Both authors contributed to the editing and final version of the manuscript.

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Data sharing statement: The data used in this manuscript was anonymously extracted from the hospital Trauma registry. This registry provides data to the National Trauma Data Bank, maintained by the American College of Surgeons. Upon request to the corresponding author, the data set used in this manuscript can be shared with interested individuals.

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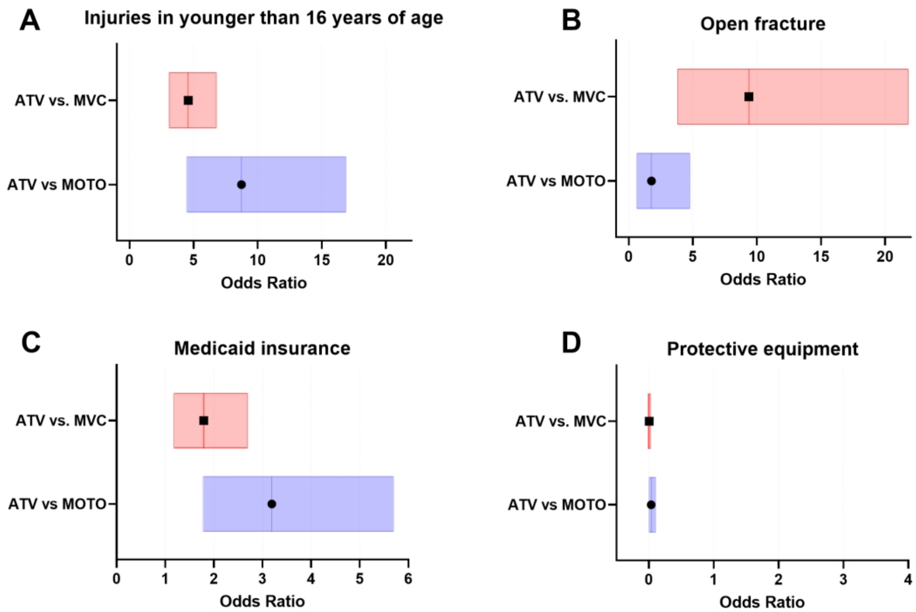
Figure legend:

Figure 1: Odds ratios with 95% confidence intervals comparing the likelihood of ATV vs. MVCs or MOTO. **A.** Likelihood for injuries occurring in children younger than 16 years. **B**. Likelihood of observing an open fracture. **C**. Likelihood of injured patients to report Medicaid as the main payer. **D**. Likelihood of reporting the use of protective equipment at the time of injury.



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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*7*
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10

		(*b*) Report category boundaries when continuous variables were categorized	11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Comparative analysis of all-terrain vehicles, motorcycle, and motor vehicle cars related trauma in a rural border community of the United States.

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Comparative analysis of all-terrain vehicles, motorcycle, and motor vehicle cars related trauma in a rural border community of the United States.

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Abstract

Introduction. There is widespread use of all-terrain vehicles (ATV) in the United States for both work-related and recreational activities. In this study, we aimed to determine the difference in injury severity, Glasgow coma scales, and length of stay between ATV-related injuries and injuries sustained from motorcycles and motor vehicle cars. **Methods.** We retrospectively analyzed ATV, motorcycle (MOTO) and motor vehicle car (MVC) injuries from a Level 2 Trauma Center between 01/01/2015 to 08/31/2020. Proportional odds regression analyses, as well as multivariable regression models, were used to analyze the data. **Results.** There were significantly more male and pediatric patients that suffered ATV-related injuries compared to MOTO or MVC injuries. Victims of ATV-related injuries were also more likely to have open fractures. Pediatric patients were less likely to sustain an injury from either MVC or MOTO accidents compared to ATV accidents. Patients with no drug use during injury and those that used protective equipment such as seat belts and child seats were significantly associated with lower Injury Severity Scores and higher Glasgow Coma Scale scores, indicating less severe injuries. **Discussion.** Pediatric patients are very likely to suffer sequela and long-term disability due to the severity of ATV-related injuries. Public awareness campaigns to educate our population, especially our youth, about unsafe ATVs' dangers are highly needed.

Strengths and Limitations

- Data collected for this study represents the majority of all ATV-related cases in the region.
- Regional hospital serviced 8 counties and approximately 1.7 million residents that allowed the formation of a large sample size.
- Data on pre-hospital deaths in the region were not able to be obtained.

What is already known on this subject?

- Compared to motorcycles and motor vehicle cars, ATV use remains loosely regulated.
- There is significant morbidity and mortality from ATV related injuries in children, especially younger than 15 years.

What this study adds?

- The likelihood of an open fracture in an ATV injury is disproportionately large compared to motorcycle and car injuries in the South Texas region.
- Although ATVs have smaller motors and travel at much slower speeds, there was no statistical difference in injury severity compared to injuries sustained from car or motorcycle accidents.
- The percentage of pediatric patients admitted for ATV injuries was three times higher than injuries from car accidents and five times higher than from motorcycle injuries.
- In the Rio Grande Valley, the use of helmets while using ATVs is extremely low (4%) and roughly half (53%) use helmets while riding a motorcycle.

Introduction

All-terrain vehicles (ATVs) also known as quad bikes, are three or four-wheeled motorized open-air vehicles with large soft tires, a relatively high center of gravity, and handlebars similar to ones found on a bicycle. They are typically designed for a single operator that straddles the vehicle's body and are primarily used for off-road activities [1]. ATVs were first developed in the 1960s as a farm vehicle and later introduced in the United States in the early 1970s [2,3]. Early generations of ATVs had a small 7-horsepower/89-cc engine and weighed less than 200 lb. Modern ATVs have engines with over 600-cc/50-hp, weigh over 600 lb., and reach speeds above 100 mph. Recreational use of ATVs increased shortly after their introduction. By the year 2000, nearly four million ATVs were sold in the U.S.A and just two years later, the U.S. Consumer Product Safety Commission (CPSC) estimated that 10.7 million four-wheeled ATVs were in operation by 2012 [4,5].

Previous literature has demonstrated that ATVs are fundamentally unstable [6]. In 1988 the CPSC imposed a 10-year ban on the sale of three-wheeled vehicles due to the dramatic injury rate. The 10-year ban was combined with a legally binding 10-year consent decree with the ATV industry to reduce injury and death. However, during that ban, four-wheeled vehicles were further developed and marketed to the public [7]. Since the ban's expiration in 1998, there has been a dramatic increase in the production of more powerful ATVs with a corresponding rise in ATV-related injuries, especially among children and young adults [8]. The annual cost of ATVs-related injuries in the U.S. was estimated at over $6.5 billion in 2003 [9]. In 2008, the Consumer Product Safety Improvement Act effectively banned the importation and distribution of three-wheeled ATVs in the United States [10]. Additionally, with the consultation of the National Highway Traffic Safety Commission, the CPSC imposed several standards on youth ATVs. The act limited the availability of manufacturers to develop smaller ATVs designed for and marketed to children as entry-level vehicles. The CPSC later acknowledged that the ban on youth ATVs might have resulted in children under 12 years riding larger, more powerful adult-sized vehicles [11]. The language in the Consumer Product Safety Improvement Act spared four-wheeled ATVs from rigorous regulations.

Without enforceable safety standards, the sale and use of four-wheel ATVs or quads remain loosely regulated. As a result, the CPSC and individual states have failed to interrupt the pattern of increasing injury and death caused by ATVs use.

According to the CPSC, close to 100,000 ATV-related injuries were treated in emergency departments in 2013 in the U.S. [4]; most injuries resulting orthopedic injuries [12]. Risk factors for such injuries include young and inexperienced riders, male gender, intoxication, lack of helmets and protective equipment, and operating on the road [13]. Children under the age of 16 are at a notably higher risk for ATV-related injuries. Although 15% of ATV riders are children, it is estimated that children account for 27% of ATV-related injuries and 28% of ATV-related deaths [5,14,15]. A study conducted in 2010 by Sawyer et al. indicated that in the United States, there was a 140% increase in ATV-related injuries among children and a 368% increase in spinal injuries from 1997 to 2006 [16]. The majority of injured children (76%) were males [16]. Children are more at risk for sustaining ATV-related injuries and death due to decreased emotional maturity, motor skill, depth perception, and experience. Children are also smaller and have lower body mass than adults, which may contribute to rollovers [17].

The southernmost region of Texas along the US/Mexico border is largely rural with a strong agricultural economy. In this region, commonly known as the Rio Grande Valley, ATVs are frequently used for both work and recreational use. The primary objectives of the study are to describe the motorized vehicle injuries at a Level 2 Trauma Center and to determine the difference in Injury Severity Scores (ISS), Glasgow coma scale scores (GCS), and hospital length of stay (LOS) between ATV-related injuries and injuries sustained from motorcycles (MOTO) and motor vehicle cars (MVC). We will also examine the effect of protective equipment use compared to other vehicles, given the lower regulations that exist for ATVs.

Methods

Design and Data Source

This is a retrospective analysis of all patients with ATV, motorcycle (MOTO), and motor vehicle car (MVC) injuries recorded as the mechanism of injury in the trauma registry from January 1, 2015 to August 31, 2020 at a regional trauma center. At the time of data collection, the hospital was one of 3 certified Level 2 Trauma hospitals in the Rio Grande Valley. The hospital serviced 8 counties and approximately 1.7 million residents. All data was collected from the hospital trauma database and included all patients who suffered an acute traumatic injury and were admitted to the hospital or transferred from another facility. The criteria for including a patient in the trauma registry follows the algorithm developed by the Committee on Trauma from the American College of Surgeons as published in the freely available National Trauma Data Standards [18]. The hospital trauma registry contains information extracted from the patient's medical record and is used to improve quality and trauma level certification by the American College of Surgeons. Data is entered into the trauma data bank by trauma nurse registrars and validated by a certified specialist in trauma registry and well as a certified abbreviated injury scaling specialist. There have been 15,482 encounters recorded in the trauma database across all injury mechanisms. Access to the database was approved by the DHR Health Institute for Research and Development Institutional Review Board.

Patient and public involvement

This is a fully de-identified retrospective research study for which patient identity was not known. Patients were not involved in the design, conduct of the research, or choice of outcome measures. This study did not involve recruitment. If accepted for publication, results will disseminated to the community with the main goal of increasing safety awareness when using ATVs.

Variables

Data elements in the trauma registry are categorized into ten broad categories of information: patients' demographic, injury, pre-hospital, emergency department, hospital procedures, pre-existing conditions, diagnosis, hospital events, outcomes, and financial information. Predictors of interest included mechanisms of injury: ATV, MOTO, and MVC, along with age, sex, ethnicity, drug use, and use of protective equipment at the time of injury. Outcome variables included presence of open fracture, injury severity score (ISS), Glascow Coma Scale on admission (GCS), hospital length of stay (LOS) measured in hours, and discharge status (including mortality) were collected. Patients were categorized as pediatric patients (age ≤ 14 years of age) or adults patients (age ≥ 15 years of age) as defined by the American College of Surgeons [19]. ISS was further categorized into minor (ISS ≤ 9), moderate (ISS 10-15), severe (ISS16-24), and very severe (ISS ≥ 25) [20]. The Glasgow Coma Scale (GCS) is used to objectively describe the extent of impaired consciousness in all types of acute medical and trauma patients. The scale assesses patients according to three aspects of responsiveness: eye-opening, motor, and verbal responses. The lowest possible total GCS is 3, while the highest is 15. Glasgow Coma Scale scores were categorized into mild (GCS 13-15), moderate (GCS 9-12), and severe (GCS 3-8) [21].

Statistical Methods

Study data was summarized using frequencies. Percentages were generated for categorical variables while median and range were used for the variables hospital LOS and ISS. Proportional odds regression analysis was used to evaluate factors associated with the ordinal type outcome variables including ISS and GCS [22]. The binary variable discharge status was analyzed using logistic regression. Multinomial logistic regression was used to analyze the mechanism as an outcome variable. Univariable regression analyses were first conducted for each of the respective outcome variables and predictors of interest. Since the sample size was large, regardless of the findings in the bivariate analyses, for each of the outcomes, we fitted multivariable regression models including all predictors of interest [23]. Potential multicollinearity effect and two-way interaction effects between the variables included in the models were examined [24, 25]. Crude and model based adjusted odds ratios (ORs) for lower versus higher response levels for the ordinal outcomes and their respective 95% confidence intervals (CIs) were estimated based on the proportional odds regression models. Similarly, crude and model based adjusted odds ratios (ORs) for dead versus alive and their respective 95% CIs were estimated based on the logistic regression model. The assumption of the proportional odds model that that the effects of any explanatory variables are *proportional* across any response levels were tested using Score test. For the proportional odds and the logistic regression models, Hosmer-Lemeshow goodness-of-fit test was performed as well. To model the highly right-skewed variable hospital LOS, measured in number of hours, several different models were probed, including Poisson, scaled Poisson, negative binomial, generalized Poisson, Conway-Maxwell Poisson model. The models were compared using the Akaike's information criteria (AIC) and the Bayesian information criteria (BIC) (also Schwarz criterion, SBC, SBIC). Based on the smallest values of these statistics, indicating a better model, as well as considering the presence of overdispersion in the data, scaled Poisson regression was used to model the outcome variable hospital LOS. Crude and model based adjusted rate ratios (RR) and their respective 95% CIs were reported based on the fitted scaled Poisson regression model. All statistical analysis were conducted using SAS 9.4 (SAS Institute, 2015). Statistical testing was two-sided and performed at a significance (α) level of 0.05.

Results

Participants and demographic characteristics

Table 1 describes the demographic variables for the patient population. The trauma registry queries returned a sample of 3942 patient records, of which 3626 were MVC, 200 were MOTO, and 116 were ATVs injuries (Table 1). Pediatric patients were 12.13% of our study population and comprising 37.93% of the ATV injured, 11.58% of the MTV injured, and 7% of the MOTO injured patients. Males were 51.55% of the study population and majority of the patients were Hispanic (Table 1). Only 29 of patients (0.74%) died due to any of the MVC, MOTO, or ATV injures.

Main outcomes

Table 2 shows the crude and model based adjusted OR and their respective 95% CI for MVC comparted to ATV injuries and MOTO compared to ATV injuries, respectively. Based on univariable analysis, females compared to males had 2.14 (95% CI: 1.45, 3.15) times higher odds of MVC versus ATV accident and 60% (OR=0.40, 95% CI: 0.24, 0.68) lower odds of MOTO accident versus ATV accident (Table 2). These odds ratios remained similar in the multivariable multinomial logistic regression after considering the effect of age, ethnicity, drug use, type of fracture, ISS groups, and GCS groups (Table 2). Pediatric patients were less likely to sustain an injury from either MVC (OR= 0.19, 95% CI: 0.12, 0.28) or MOTO (OR=0.15, 95% CI: 0.08, 0.31) accidents compared to ATV accidents controlling for the effect of all other variables included in the model (Table 2). Patients with MVC injuries had 78% lower odds of sustaining an open fracture (OR=0.22, 95% CI: 0.07, 0.73) compared to ATV-related injuries, controlling for the effect of all other variables include in the model (Table 2). There was a significant difference in the distribution of the ISS across the mechanism of injury ($p<0.0001$) (Table 1), and the crude odds of a severe ISS versus very severe ISS was 89% lower in patients with MVC compared to ATV injuries (OR=0.11, 95% CI: 0.01, 0.90) (Table 2). However this effect was not significant in the multivariable model adjusting for the effect of age, ethnicity, drug use, type of fracture, and GSC groups (Table 2).

Table 3 shows the results from multivariable proportional odds regression for ISS groups. MVC patients were less likely to sustain severe injuries (higher ISS scores) compared to MOTO patients (OR=0.60, 95% CI: 0.38, 0.94), controlling for the effect of age, sex, ethnicity, drug use, and protective equipment (Table 3). Female patients had 31% lower odds of more severe ISS than male patients (OR= 0.69, 95% CI: 0.51, 0.94) controlling for the effect of mechanism, age, ethnicity, drug use, and protective equipment. Patients who were under the influence compared to their counterparts had 3.73 (95% CI: 2.46, 4.65) times higher odds more severe ISS. Those who utilized protective equipment at the time of the injury were less likely to have a more severe ISS than patients who did not utilize any protective equipment, controlling for the effect of the variables included in the model (Table 3).

Table 4 shows the results from multivariable proportional odds regression for GCS groups. Female patients were less likely to have a more severe score compared to male patients

(OR= 0.63, 95% CI: 0.41, 0.98) controlling for the effect of mechanism, age, ethnicity, drug use, and use protective equipment. As in the case of ISS, patients who were not under the influence were less likely to have a more severe GCS compared to their counterpart (OR= 0.38, 95% CI: 0.24, 0.62) and those who utilized either a seat belt or car seat at the time of injury were less likely to have a more severe GCS compared to patients who did not utilize any protective equipment (OR= 0.21, 95% CI: 0.14, 0.33) controlling for all other variable included in the model (Table 4). Further analysis showed MVC-injured patients had 4.25 (1.05, 17.21) times higher odds of a severe GCS score compared to MOTO patients (Table 4).

Based on multivariable logistic regression for discharge status, females had 60% lower odds (OR=0.40, 95% CI: 0.18, 0.88) of dying due to injuries, controlling for the effect of age, ethnicity and drug use (Table 5).

Table 6 displays the results based on fitted multivariable scaled Poisson regression for hospital LOS. Pediatric patients that were not under the influence at the time of injury and used protective equipment had a lower rate of hospital LOS compared to their respective counterparts, controlling for the effect of sex and ethnicity (Table 6).

Discussion

This study showed that ATV-related injuries reported from a Level 2 Trauma Center were more common among pediatric and male patients. The percentage of pediatric patients admitted for ATV injuries was three times higher than MVC injuries and five times higher than MOTO injuries. Similar results have been found in the literature [26-28]. Additionally, victims of ATV-related injuries had significantly higher odds of sustaining an open fracture compared to patients in the MVC cohort. Furthermore, data showed no statistical difference in injury severity between the difference mechanisms of injury (ATV vs MVC vs MOTO) even though ATVs have smaller motors and travel at much slower speeds. There is clear evidence that ATV-related injuries continue to be a significant cause of injuries among pediatric patients.

Unlike motor vehicles, ATVs are open-air vehicles that lack a shell protection to its operator/passenger. This increases the likelihood of sustaining more severe injuries and soft tissue damage even with low-speed injuries and was evidenced by data from this study that showed open fractures in ATV injuries was higher than in MVC or MOTO cohorts. Most open fractures and soft tissue injuries require multiple interventions to lower the risk of infection and may require several surgical specialties such as plastic surgeons, and vascular surgeons to treat the patient. Rehabilitation practices for traumatic brain injury, spine injuries, and fractures depend on the injury severity and there exists a potential detrimental impact on daily life activities [29,30]. Therefore, open fractures potentially result in increased risk to patients and could affect patient outcomes.

Equally concerning was the lack of protective equipment, e.g., seat belts, child seats, and helmets, used by patients in each of the mechanistic cohorts. Only 4% of patients that sustained ATV injuries were wearing a helmet whereas only about half of MOTO patients were wearing one. Previous studies have reported low use of protective equipment in ATV riders [31, 32], however, the use of protective equipment was exceptionally low in this cohort. The data demonstrated that patients who wore protective equipment had a lower odds of severe injuries, severe Glasgow scores, and had a lower rate of hospital LOS. Unmistakably, using protective equipment improves patient outcomes.

Limitations

There were few deaths reported in the dataset and mortality averages did not follow the previously reported national averages [33], with the most reasonable explanation for this being a small sample size. The data on pre-hospital deaths in the region were not able to be obtained therefore conclusions on mortality were not able to be made. This may have given insight on the mortality rate associated with ATV-related injuries in the region. Other than injury severity, classification of injury using the International Classification of Diseases (ICD-10-CM) was not conducted as it was outside the scope of the current study. However, future studies that investigate injury types are likely to give insight on long-term sequelae and disabilities.

Conclusions

Public awareness campaigns to educate on ATV-related injuries, particularly in the pediatric population are needed. A concerted effort to highlight the vulnerability of young riders and the importance of protective equipment is a vital step in curtailing ATV-related injuries. With similar injury severity among ATV, MOTO, and MVC injuries, similar regulations and laws regarding the use of protective devices should be imposed. Additionally, reimaging the configuration of ATVs with implementation of anti-roll bars, protective shells, or seat belts and revisiting the regulation of ATV use could also help reduce the risk of injuries.

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TABLES

Table 1: Demographic variables for DHR patients with traumatic injuries occurring when using MVC, MOTO, or ATV (n=3942).

Variables	Total (n=3942)	MVC (n=3626)	MOTO (n=200)	ATV (n=116)	p-value*
Age, mean (SD)	32.66 (10.06)	32.98 (19.28)	33.56 (15.37)	21.22 (13.98)	**<0.0001**
Age groups, n (%)					
0-14 years	478 (12.13)	420 (11.58)	14 (7.0)	44 (37.93)	**<0.0001**
>=15 years	3464 (87.87)	3206 (88.42)	186 (93.00)	72 (62.07)	
Sex, n (%)					
Male	2032 (51.55)	1671 (46.08)	164 (82.00)	75 (64.66)	**<0.0001**
Female	1910 (48.45)	1955 (53.92)	36 (18.00)	41 (35.34)	
Ethnicity (n=3940), n (%)					
Hispanic	3689 (93.63)	3398 (93.76)	177 (88.50)	114 (98.28)	**0.0024**
Non-Hispanic	251 (6.37)	226 (6.24)	23 (11.50)	2 (1.72)	
Drugs (n=3908), n (%)					
Yes	460 (11.77)	398 (11.08)	46 (23.00)	16 (13.91)	**<0.0001**
No	3448 (88.23)	3195 (88.92)	154 (77.00)	99 (86.09)	
Discharge status, n (%)					
Dead	29 (0.74)	29 (0.80)	0 (0)	0 (0)	0.9996
Alive	3913 (99.26)	2597 (99.20)	200 (100.00)	116 (100.00)	
Open fracture, n (%)					
Yes	38 (0.96)	24 (0.66)	7 (3.50)	7 (6.03)	**<0.0001**
No	3904 (99.04)	3602 (99.34)	193 (96.50)	109 (93.97)	
ISS (n=3019), median (range)	1 (74)	1 (74)	4 (32)	4 (25)	**<0.0001**
ISS groups (n=3019), n (%)					
Minor	2782 (92.15)	2533 (92.85)	159 (85.48)	90 (85.71)	**<0.0001**
Moderate	89 (2.95)	73 (2.68)	10 (5.38)	6 (5.71)	
Severe	76 (2.52)	57 (2.09)	11 (5.91)	8 (7.62)	
Very Severe	72 (2.38)	65 (2.38)	6 (3.23)	1 (0.95)	
GCS groups (n=3914), n (%)					
Mild	3799 (97.06)	3493 (97.00)	193 (97.47)	113 (98.26)	0.6714
Moderate	56 (1.43)	51 (1.42)	4 (2.02)	1 (0.87)	
Severe	59 (1.51)	57 (1.58)	1 (0.51)	1 (0.87)	
LOS in hours, median (range)	3.10 (1557.53)	3.02 (1557.53)	5.04 (992.33)	3.70 (812.23)	**<0.0001**
Protective Equipment (n=3809), n (%)					
Seat belt/Child seat	2993 (78.68)	2993 (85.17)	0 (0)	0 (0)	**<0.0001**
Protective Clothing/Helmet	106 (2.79)	0 (0)	102 (53.13)	4 (4.08)	
No Protective Equipment	705 (18.53)	521 (14.83)	90 (46.88)	94 (95.92)	

* p-values are based on chi-square test for non-zero regression coefficients in univariable logistic regression analysis

Table 2: Model based adjusted OR (95% CI) based on multinomial logistic regression for mechanism of injury.

Variable	MVC vs. ATV Adjusted OR (95% CI)	p-value	MOTO vs. ATV Adjusted OR (95% CI)	p-value
Age groups, n (%)				
0-14 years	**0.19 (0.12, 0.29)**	**<.0001**	**0.15 (0.08, 0.31)**	**<.0001**
>=15 years	reference		reference	
Sex, n (%)				
Male	reference		reference	
Female	**2.14 (1.39, 3.27)**	**0.0005**	**0.5 (0.29, 0.88)**	**0.016**
Ethnicity, n (%)				
Hispanic	0.17 (0.02, 1.23)	0.0794	**0.1 (0.01, 0.75)**	**0.0254**
Non-Hispanic	reference		reference	
Drugs, n (%)				
Yes	0.97 (0.52, 1.81)	0.9207	1.36 (0.67, 2.76)	0.4006
No	reference		reference	
Open fracture, n (%)				
Yes	**0.22 (0.07, 0.73)**	**0.0132**	0.47 (0.10, 2.10)	0.3202
No	reference		reference	
ISS groups, n (%)				
Minor	0.68 (0.08, 5.91)	0.7222	0.36 (0.04, 3.72)	0.3918
Moderate	0.3 (0.03, 2.99)	0.3052	0.27 (0.02, 3.29)	0.3032
Severe	0.17 (0.02, 1.59)	0.1203	0.27 (0.02, 3.00)	0.2829
Very Severe	reference		reference	
GCS groups, n (%)				
Mild	0.32 (0.04, 2.89)	0.3089	2.42 (0.12, 48.13)	0.5631
Moderate	0.59 (0.03, 10.79)	0.725	3.1 (0.08, 115.93)	0.5399
Severe	reference		reference	

Table 3: Model based adjusted OR (95% CI) based on proportional odds regression for higher versus lower ISS

Variable	OR (95% CI)	p-value
Mechanism MVC vs ATV	0.95 (0.49, 1.81)	0.8662
Mechanism MOTO vs ATV	0.87 (0.38, 1.97)	0.7375
Mechanism MVC vs MOTO	0.60 (0.38, 0.94)	**0.0245**
Sex Female vs Male	0.69 (0.51, 0.94)	**0.0195**
Pediatric vs Adults	0.83 (0.49, 1.38)	0.4665
Hispanic vs non-Hispanic	0.90 (0.51, 1.61)	0.7333
Drug Use vs No Drug Use	3.73 (2.46, 4.65)	**<.0001**
Child seat/Seat belt vs No Protective Equipment	0.29 (0.21, 0.40)	**<.0001**
Protective Clothing/Helmet vs No Protective Equipment	0.74 (0.33, 1.66)	0.4589

Table 4: Model based adjusted OR (95% CI) based on proportional odds regression for higher versus lower GCS

Variable	OR (95% CI)	p-value
Mechanism MVC vs ATV	4.17 (0.98, 17.77)	**0.0410**
Mechanism MOTO vs ATV	0.98 (0.14, 6.73)	0.0533
Mechanism MVC vs MOTO	4.25 (1.05, 17.21)	0.9853
Sex Female vs Male	0.63 (0.41, 0.98)	**0.0426**
Pediatric vs Adults	0.99 (0.51, 1.92)	0.9828
Hispanic vs non-Hispanic	1.41 (0.51, 3.93)	0.5066
Drug Use vs No Drug Use	0.38 (0.24, 0.62)	**<.0001**
Child seat/Seat belt vs No Protective Equipment	0.21 (0.14, 0.33)	**<.0001**
Protective Clothing/Helmet vs No Protective Equipment	1.19 (0.21, 6.89)	0.8471

Table 5: Model based adjusted OR (95% CI) based on multivariable logistic regression for discharge status

Variable	OR (95% CI)	p-value
Sex Female vs Male	0.40 (0.18, 0.88)	**0.0228**
Pediatric vs Adults	0.78 (0.23, 2.61)	0.6873
Hispanic vs non-Hispanic	0.64 (0.19, 2.15)	0.4754
Drug Use vs No Drug Use	2.25 (0.53, 9.61)	0.2736

Table 6: Model based adjusted RR (95% CI) based on scaled Poisson regression for hospital LOS

Variable	RR (95% CI)	p-value
Sex Female vs Male	0.85 (0.69, 1.05)	0.1405
Pediatric vs Adults	0.53 (0.33, 0.86)	**0.0096**
Hispanic vs non-Hispanic	0.89 (0.54, 1.22)	0.3161
Drug Use vs No Drug Use	3.36 (2.65, 4.25)	**<.0001**
Child seat /Seat belt vs No Protective Equipment	0.43 (0.32, 0.53)	**<.0001**

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Ethics approval statements: This study received approval by the DHR Health Institute for Research and Development Institutional Review Board (protocol number 1574841-2 approved on 08/18/2020).

Contributions statement: HSE conceptualized the study, wrote the first manuscript draft, and supervised the overall project. ATR, KV, and GR extracted and analyzed the data. MGB, KV, and GR completed reviewer revisions and wrote final draft of the manuscript. All authors contributed to the editing and final version of the manuscript.

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Data Availability Statement: The data was extracted from a trauma registry at a regional trauma center from January 1, 2015 to August 31, 2020. The de-identified data is available upon reasonable request.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	8-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-10

		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Comparative analysis of all-terrain vehicles, motorcycle, and automobile-related trauma in a rural border community of the United States.

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Comparative analysis of all-terrain vehicles, motorcycle, and automobile-related trauma in a rural border community of the United States.

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Abstract

Introduction. There is widespread use of all-terrain vehicles (ATV) in the United States for both work-related and recreational activities. In this study, we aimed to determine the difference in injury severity, Glasgow coma scales, and length of stay between ATV-related injuries and injuries sustained from motorcycles and automobiles. **Methods.** We retrospectively analyzed ATV, motorcycle (MOTO) and automobile (AUTO) injuries from a Level 2 Trauma Center between 01/01/2015 to 08/31/2020. Proportional odds regression analyses, as well as multivariable regression models, were used to analyze the data. **Results.** There were significantly more male and pediatric patients that suffered ATV-related injuries compared to MOTO or AUTO injuries. Victims of ATV-related injuries were also more likely to have open fractures. Pediatric patients were less likely to sustain an injury from either AUTO or MOTO accidents compared to ATV accidents. Patients with no drug use during injury and those that used protective equipment such as seat belts and child seats were significantly associated with lower Injury Severity Scores and higher Glasgow Coma Scale scores, indicating less severe injuries. **Discussion.** Pediatric patients are very likely to suffer sequela and long-term disability due to the severity of ATV-related injuries. Public awareness campaigns to educate our population, especially our youth, about the danger of ATV use are highly needed.

Strengths and Limitations

- Data collected for this study represents the majority of all ATV-related cases in the region.
- Regional hospital serviced 8 counties and approximately 1.7 million residents that allowed the formation of a large sample size.
- Data on pre-hospital deaths in the region were not able to be obtained.

What is already known on this subject?

- Compared to motorcycles and automobiles, ATV use remains loosely regulated.
- There is significant morbidity and mortality from ATV related injuries in children, especially younger than 15 years.

What this study adds?

- The likelihood of an open fracture in an ATV injury is disproportionately large compared to motorcycle and automobile injuries in the South Texas region.
- Although ATVs have smaller motors and travel at much slower speeds, there was no statistical difference in injury severity compared to injuries sustained from car or motorcycle accidents.
- The percentage of pediatric patients admitted for ATV injuries was three times higher than injuries from automobile accidents and five times higher than from motorcycle injuries.

- In the Rio Grande Valley, the use of helmets while using ATVs is extremely low (4%) and roughly half (53%) use helmets while riding a motorcycle.

Introduction

All-terrain vehicles (ATVs) also known as quad bikes, are three or four-wheeled motorized open-air vehicles with large soft tires, a relatively high center of gravity, and handlebars similar to ones found on a bicycle. They are typically designed for a single operator that straddles the vehicle's body and are primarily used for off-road activities [1]. ATVs were first developed in the 1960s as a farm vehicle and later introduced in the United States in the early 1970s [2,3]. Early generations of ATVs had a small 7-horsepower/89-cc engine and weighed less than 200 lb. Modern ATVs have engines with over 600-cc/50-hp, weigh over 600 lb., and reach speeds above 100 mph. Recreational use of ATVs increased shortly after their introduction. By the year 2000, nearly four million ATVs were sold in the U.S.A and by 2012, the U.S. Consumer Product Safety Commission (CPSC) estimated that 10.7 million four-wheeled ATVs were in operation. [4,5].

According to the CPSC, close to 100,000 ATV-related injuries were treated in emergency departments in 2013 in the U.S. [4]; most injuries resulting orthopedic injuries [6]. Risk factors for such injuries include young and inexperienced riders, male gender, intoxication, lack of helmets and protective equipment, and operating on the road [7]. Children under the age of 16 are at a notably higher risk for ATV-related injuries. Although 15% of ATV riders are children, it is estimated that children account for 27% of ATV-related injuries and 28% of ATV-related deaths [5,8,9]. A study conducted in 2010 by Sawyer et al. indicated that in the United States, there was a 140% increase in ATV-related injuries among children and a 368% increase in spinal injuries from 1997 to 2006 [10]. The majority of injured children (76%) were males [10]. Children are more at risk for sustaining ATV-related injuries and death due to decreased emotional maturity, motor skill, depth perception, and experience. Children are also smaller and have lower body mass than adults, which may contribute to rollovers [11].

The southernmost region of Texas along the US/Mexico border is largely rural with a strong agricultural economy. In this region, commonly known as the Rio Grande Valley, ATVs are frequently used for both work and recreational use. The primary objectives of the study are to determine the difference in Injury Severity Scores (ISS), Glasgow coma scale scores (GCS), and hospital length of stay (LOS) between ATV-related injuries and injuries sustained from motorcycles (MOTO) and automobiles (AUTO) at a Level 2 Trauma Center. We will also examine the effect of protective equipment use on injury severity and length of stay, given the lower regulations that exist for ATVs.

Methods

Design and Data Source

This is a retrospective analysis of all patients with ATV, motorcycle (MOTO), and automobile (AUTO) injuries recorded as the mechanism of injury in the trauma registry from January 1, 2015 to August 31, 2020 at a regional trauma center. At the time of data collection, the hospital was one of 3 certified Level 2 Trauma hospitals in the Rio Grande Valley. The hospital serviced 8 counties and approximately 1.7 million residents. All data was collected from the hospital trauma database and included all patients who suffered an acute traumatic injury and were admitted to the hospital or transferred from another facility. The criteria for including a patient in the trauma registry follows the algorithm developed by the Committee on Trauma from the American College of Surgeons as published in the freely available National Trauma Data Standards [12]. The hospital trauma registry contains information extracted from the patient's medical record and is used to improve quality and trauma level certification by the American

College of Surgeons. Data is entered into the trauma data bank by trauma nurse registrars and validated by a certified specialist in trauma registry and well as a certified abbreviated injury scaling specialist. There have been 15,482 encounters recorded in the trauma database across all injury mechanisms. Access to the database was approved by the DHR Health Institute for Research and Development Institutional Review Board.

Patient and Public Involvement

This is a fully de-identified retrospective research study for which patient identity was not known. Patients were not involved in the design, conduct of the research, or choice of outcome measures. This study did not involve recruitment. If accepted for publication, results will disseminated to the community with the main goal of increasing safety awareness when using ATVs.

Variables

Data elements in the trauma registry are categorized into ten broad categories of information: patients' demographic, injury, pre-hospital, emergency department, hospital procedures, pre-existing conditions, diagnosis, hospital events, outcomes, and financial information. Predictors of interest included mechanisms of injury: ATV, MOTO, and AUTO, along with age, sex, ethnicity, drug use, and use of protective equipment at the time of injury. Outcome variables included presence of open fracture, injury severity score (ISS), Glascow Coma Scale on admission (GCS), hospital length of stay (LOS) measured in hours, and discharge status (including mortality) were collected. Patients were categorized as pediatric patients (age $\leq$ 14 years of age) or adults patients (age $\geq$ 15 years of age) as defined by the American College of Surgeons [13]. ISS was further categorized into minor (ISS $\leq$ 9), moderate (ISS 10-15), severe

(ISS16-24), and very severe (ISS ≥ 25) [14]. The Glasgow Coma Scale (GCS) is used to objectively describe the extent of impaired consciousness in all types of acute medical and trauma patients. The scale assesses patients according to three aspects of responsiveness: eye-opening, motor, and verbal responses. The lowest possible total GCS is 3, while the highest is 15. Glasgow Coma Scale scores were categorized into mild (GCS 13-15), moderate (GCS 9-12), and severe (GCS 3-8) [15].

Statistical Methods

Study data was summarized using frequencies. Percentages were generated for categorical variables while median and range were used for the variables hospital LOS and ISS. Proportional odds regression analysis was used to evaluate factors associated with the ordinal type outcome variables including ISS and GCS [16]. The binary variable discharge status was analyzed using logistic regression. Multinomial logistic regression was used to analyze the mechanism as an outcome variable. Univariable regression analyses were first conducted for each of the respective outcome variables and predictors of interest. Since the sample size was large, regardless of the findings in the bivariate analyses, for each of the outcomes, we fitted multivariable regression models including all predictors of interest [17]. Potential multicollinearity effect and two-way interaction effects between the variables included in the models were examined [18, 19]. Crude and model based adjusted odds ratios (ORs) for lower versus higher response levels for the ordinal outcomes and their respective 95% confidence intervals (CIs) were estimated based on the proportional odds regression models. Similarly, crude and model based adjusted odds ratios (ORs) for dead versus alive and their respective 95% CIs were estimated based on the logistic regression model. The assumption of the proportional odds model that that the effects of any explanatory variables are *proportional* across any response levels were tested using Score test. For the proportional odds and the logistic regression models, Hosmer-Lemeshow goodness-of-fit test was performed as well. To model the highly right-skewed variable hospital LOS, measured in number of hours, as well as considering the presence of overdispersion in the data, quasi-Poisson regression was used.. The models were compared using the Akaike's information criteria (AIC) and the Bayesian information criteria (BIC) (also Schwarz criterion, SBC, SBIC).. Crude and model based adjusted rate ratios (RR) and their respective 95% CIs were reported based on a quasi-Poisson regression model. All statistical analysis were conducted using SAS 9.4 (SAS Institute, 2015). Statistical testing was two-sided and performed at a significance (α) level of 0.05.

Results

Participants and demographic characteristics

Table 1 describes the demographic variables for the patient population. The trauma registry queries returned a sample of 3942 patient records, of which 3626 were AUTO, 200 were MOTO, and 116 were ATVs injuries (Table 1). Pediatric patients were 12.13% of our study population and comprising 37.93% of the ATV injured, 11.58% of the MTV injured, and 7% of the MOTO injured patients. Males were 51.55% of the study population and majority of the patients were Hispanic (Table 1). Only 29 of patients (0.74%) died due to any of the AUTO, MOTO, or ATV injures.

Main outcomes

Table 2 shows the crude and model based adjusted OR and their respective 95% CI for AUTO comparted to ATV injuries and MOTO compared to ATV injuries, respectively. Based on univariable analysis, females compared to males had 2.14 (95% CI: 1.45, 3.15) times higher odds of AUTO versus ATV accident and 60% (OR=0.40, 95% CI: 0.24, 0.68) lower odds of MOTO accident versus ATV accident (Table 2). These odds ratios remained similar in the multivariable multinomial logistic regression after considering the effect of age, ethnicity, drug use, type of fracture, ISS groups, and GCS groups (Table 2). Pediatric patients were less likely to sustain an injury from either AUTO (OR= 0.19, 95% CI: 0.12, 0.28) or MOTO (OR=0.15, 95% CI: 0.08, 0.31) accidents compared to ATV accidents controlling for the effect of all other variables included in the model (Table 2). Patients with AUTO injuries had 78% lower odds of sustaining an open fracture (OR=0.22, 95% CI: 0.07, 0.73) compared to ATV-related injuries, controlling for the effect of all other variables include in the model (Table 2). There was a significant difference in the distribution of the ISS across the mechanism of injury ($p<0.0001$) (Table 1), and the crude odds of a severe ISS versus very severe ISS was 89% lower in patients with AUTO compared to ATV injuries (OR=0.11, 95% CI: 0.01, 0.90) (Table 2). However this effect was not significant in the multivariable model adjusting for the effect of age, ethnicity, drug use, type of fracture, and GSC groups (Table 2).

Table 3 shows the results from multivariable proportional odds regression for ISS groups. AUTO patients were less likely to sustain severe injuries (higher ISS scores) compared to MOTO patients (OR=0.60, 95% CI: 0.38, 0.94), controlling for the effect of age, sex, ethnicity, drug use, and protective equipment (Table 3). Female patients had 31% lower odds of more severe ISS than male patients (OR= 0.69, 95% CI: 0.51, 0.94) controlling for the effect of mechanism, age, ethnicity, drug use, and protective equipment. Patients who were under the influence compared to their counterparts had 3.73 (95% CI: 2.46, 4.65) times higher odds more severe ISS. Those who utilized protective equipment at the time of the injury were less likely to have a more severe ISS than patients who did not utilize any protective equipment, controlling for the effect of the variables included in the model (Table 3).

Table 4 shows the results from multivariable proportional odds regression for GCS groups. Female patients were less likely to have a more severe score compared to male patients (OR= 0.63, 95% CI: 0.41, 0.98) controlling for the effect of mechanism, age, ethnicity, drug use, and use protective equipment. As in the case of ISS, patients who were not under the influence were less likely to have a more severe GCS compared to their counterpart (OR= 0.38, 95% CI: 0.24, 0.62) and those who utilized either a seat belt or car seat at the time of injury were less likely to have a more severe GCS compared to patients who did not utilize any protective equipment (OR= 0.21, 95% CI: 0.14, 0.33) controlling for all other variable included in the model (Table 4). Further analysis showed AUTO-injured patients had 4.25 (1.05, 17.21) times higher odds of a severe GCS score compared to MOTO patients (Table 4).

Based on multivariable logistic regression for discharge status, females had 60% lower odds (OR=0.40, 95% CI: 0.18, 0.88) of dying due to injuries, controlling for the effect of age, ethnicity and drug use (Table 5).

Table 6 displays the results based on fitted multivariable scaled Poisson regression for hospital LOS. Pediatric patients that were not under the influence at the time of injury and used protective equipment had a lower rate of hospital LOS compared to their respective counterparts, controlling for the effect of sex and ethnicity (Table 6).

Discussion

Previous literature has demonstrated that ATVs are fundamentally unstable [20]. In 1988 the CPSC imposed a 10-year ban on the sale of three-wheeled vehicles due to the dramatic injury rate. The 10-year ban was combined with a legally binding 10-year consent decree with the

ATV industry to reduce injury and death. However, since the ban's expiration in 1998, there has been a dramatic increase in the production of more powerful ATVs with a corresponding rise in ATV-related injuries, especially among children and young adults [21].

This study showed that ATV-related injuries reported from a Level 2 Trauma Center were more common among pediatric and male patients. The percentage of pediatric patients admitted for ATV injuries was three times higher than AUTO injuries and five times higher than MOTO injuries. Similar results have been found in the literature [22-24]. Additionally, victims of ATV-related injuries had significantly higher odds of sustaining an open fracture compared to patients in the AUTO cohort. Furthermore, data showed no statistical difference in injury severity between the difference mechanisms of injury (ATV vs AUTO vs MOTO) even though ATVs have smaller motors and travel at much slower speeds. There is clear evidence that ATV-related injuries continue to be a significant cause of injuries among pediatric patients.

Unlike automobiles, ATVs are open-air vehicles that lack a shell protection to its operator/passenger. This increases the likelihood of sustaining more severe injuries and soft tissue damage even with low-speed injuries and was evidenced by data from this study that showed open fractures in ATV injuries was higher than in AUTO or MOTO cohorts. Most open fractures and soft tissue injuries require multiple interventions to lower the risk of infection and may require several surgical specialties such as plastic surgeons, and vascular surgeons to treat the patient. Rehabilitation practices for traumatic brain injury, spine injuries, and fractures depend on the injury severity and there exists a potential detrimental impact on daily life activities [25, 26]. Therefore, open fractures potentially result in increased risk to patients and could affect patient outcomes.

Equally concerning was the lack of protective equipment, e.g., seat belts, child seats, and helmets, used by patients in each of the mechanistic cohorts. Only 4% of patients that sustained ATV injuries were wearing a helmet whereas only about half of MOTO patients were wearing one. Previous studies have reported low use of protective equipment in ATV riders [27, 28], however, the use of protective equipment was exceptionally low in this cohort. The data demonstrated that patients who wore protective equipment had a lower odds of severe injuries, severe Glasgow scores, and had a lower rate of hospital LOS. Unmistakably, using protective equipment improves patient outcomes.

Limitations

There were few deaths reported in the dataset and mortality averages did not follow the previously reported national averages [29], with the most reasonable explanation for this being a small sample size. The data on pre-hospital deaths in the region were not able to be obtained therefore conclusions on mortality were not able to be made. This may have given insight on the mortality rate associated with ATV-related injuries in the region. Other than injury severity, classification of injury using the International Classification of Diseases (ICD-10-CM) was not conducted as it was outside the scope of the current study. However, future studies that investigate injury types are likely to give insight on long-term sequelae and disabilities.

Conclusions

Without enforceable safety standards, the sale and use of four-wheel ATVs or quads remain loosely regulated. As a result, the pattern of increasing injury and death caused by ATVs continues. Public awareness campaigns to educate on ATV-related injuries, particularly in the pediatric population are needed. A concerted effort to highlight the vulnerability of young riders and the importance of protective equipment is a vital step in curtailing ATV-related injuries. With similar injury severity among ATV, MOTO, and AUTO injuries, similar regulations and laws regarding the use of protective devices should be imposed. Additionally, reimaging the configuration of ATVs with implementation of anti-roll bars, protective shells, or seat belts and revisiting the regulation of ATV use could also help reduce the risk of injuries.

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TABLES

Table 1: Demographic variables for DHR patients with traumatic injuries occurring when using AUTO, MOTO, or ATV (n=3942).

Variables	Total (n=3942)	AUTO (n=3626)	MOTO (n=200)	ATV (n=116)	p-value*
Age, mean (SD)	32.66 (10.06)	32.98 (19.28)	33.56 (15.37)	21.22 (13.98)	**<0.0001**
Age groups, n (%)					
0-14 years	478 (12.13)	420 (11.58)	14 (7.0)	44 (37.93)	**<0.0001**
>=15 years	3464 (87.87)	3206 (88.42)	186 (93.00)	72 (62.07)	
Sex, n (%)					
Male	2032 (51.55)	1671 (46.08)	164 (82.00)	75 (64.66)	**<0.0001**
Female	1910 (48.45)	1955 (53.92)	36 (18.00)	41 (35.34)	
Ethnicity (n=3940), n (%)					
Hispanic	3689 (93.63)	3398 (93.76)	177 (88.50)	114 (98.28)	**0.0024**
Non-Hispanic	251 (6.37)	226 (6.24)	23 (11.50)	2 (1.72)	
Drugs (n=3908), n (%)					
Yes	460 (11.77)	398 (11.08)	46 (23.00)	16 (13.91)	**<0.0001**
No	3448 (88.23)	3195 (88.92)	154 (77.00)	99 (86.09)	
Discharge status, n (%)					
Dead	29 (0.74)	29 (0.80)	0 (0)	0 (0)	0.9996
Alive	3913 (99.26)	2597 (99.20)	200 (100.00)	116 (100.00)	
Open fracture, n (%)					
Yes	38 (0.96)	24 (0.66)	7 (3.50)	7 (6.03)	**<0.0001**
No	3904 (99.04)	3602 (99.34)	193 (96.50)	109 (93.97)	
ISS (n=3019), median (range)	1 (74)	1 (74)	4 (32)	4 (25)	**<0.0001**
ISS groups (n=3019), n (%)					
Minor	2782 (92.15)	2533 (92.85)	159 (85.48)	90 (85.71)	**<0.0001**
Moderate	89 (2.95)	73 (2.68)	10 (5.38)	6 (5.71)	
Severe	76 (2.52)	57 (2.09)	11 (5.91)	8 (7.62)	
Very Severe	72 (2.38)	65 (2.38)	6 (3.23)	1 (0.95)	
GCS groups (n=3914), n (%)					
Mild	3799 (97.06)	3493 (97.00)	193 (97.47)	113 (98.26)	0.6714
Moderate	56 (1.43)	51 (1.42)	4 (2.02)	1 (0.87)	
Severe	59 (1.51)	57 (1.58)	1 (0.51)	1 (0.87)	
LOS in hours, median (range)	3.10 (1557.53)	3.02 (1557.53)	5.04 (992.33)	3.70 (812.23)	**<0.0001**
Protective Equipment (n=3809), n (%)					
Seat belt/Child seat	2993 (78.68)	2993 (85.17)	0 (0)	0 (0)	**<0.0001**
Protective Clothing/Helmet	106 (2.79)	0 (0)	102 (53.13)	4 (4.08)	
No Protective Equipment	705 (18.53)	521 (14.83)	90 (46.88)	94 (95.92)	

* p-values are based on chi-square test for non-zero regression coefficients in univariable logistic regression analysis

Table 2: Model based adjusted OR (95% CI) based on multinomial logistic regression for mechanism of injury.

Variable	AUTO vs. ATV Adjusted OR (95% CI)	p-value	MOTO vs. ATV Adjusted OR (95% CI)	p-value
Age groups, n (%)				
0-14 years	**0.19 (0.12, 0.29)**	**<.0001**	**0.15 (0.08, 0.31)**	**<.0001**
>=15 years	reference		reference	
Sex, n (%)				
Male	reference		reference	
Female	**2.14 (1.39, 3.27)**	**0.0005**	**0.5 (0.29, 0.88)**	**0.016**
Ethnicity, n (%)				
Hispanic	0.17 (0.02, 1.23)	0.0794	**0.1 (0.01, 0.75)**	**0.0254**
Non-Hispanic	reference		reference	
Drugs, n (%)				
Yes	0.97 (0.52, 1.81)	0.9207	1.36 (0.67, 2.76)	0.4006
No	reference		reference	
Open fracture, n (%)				
Yes	**0.22 (0.07, 0.73)**	**0.0132**	0.47 (0.10, 2.10)	0.3202
No	reference		reference	
ISS groups, n (%)				
Minor	0.68 (0.08, 5.91)	0.7222	0.36 (0.04, 3.72)	0.3918
Moderate	0.3 (0.03, 2.99)	0.3052	0.27 (0.02, 3.29)	0.3032
Severe	0.17 (0.02, 1.59)	0.1203	0.27 (0.02, 3.00)	0.2829
Very Severe	reference		reference	
GCS groups, n (%)				
Mild	0.32 (0.04, 2.89)	0.3089	2.42 (0.12, 48.13)	0.5631
Moderate	0.59 (0.03, 10.79)	0.725	3.1 (0.08, 115.93)	0.5399
Severe	reference		reference	

Table 3: Model based adjusted OR (95% CI) based on proportional odds regression for higher versus lower ISS

Variable	OR (95% CI)	p-value
Mechanism AUTO vs ATV	0.95 (0.49, 1.81)	0.8662
Mechanism MOTO vs ATV	0.87 (0.38, 1.97)	0.7375
Mechanism AUTO vs MOTO	0.60 (0.38, 0.94)	**0.0245**
Sex Female vs Male	0.69 (0.51, 0.94)	**0.0195**
Pediatric vs Adults	0.83 (0.49, 1.38)	0.4665
Hispanic vs non-Hispanic	0.90 (0.51, 1.61)	0.7333
Drug Use vs No Drug Use	3.73 (2.46, 4.65)	**<.0001**
Child seat/Seat belt vs No Protective Equipment	0.29 (0.21, 0.40)	**<.0001**
Protective Clothing/Helmet vs No Protective Equipment	0.74 (0.33, 1.66)	0.4589

Table 4: Model based adjusted OR (95% CI) based on proportional odds regression for higher versus lower GCS

Variable	OR (95% CI)	p-value
Mechanism AUTO vs ATV	4.17 (0.98, 17.77)	**0.0410**
Mechanism MOTO vs ATV	0.98 (0.14, 6.73)	0.0533
Mechanism AUTO vs MOTO	4.25 (1.05, 17.21)	0.9853
Sex Female vs Male	0.63 (0.41, 0.98)	**0.0426**
Pediatric vs Adults	0.99 (0.51, 1.92)	0.9828
Hispanic vs non-Hispanic	1.41 (0.51, 3.93)	0.5066
Drug Use vs No Drug Use	0.38 (0.24, 0.62)	**<.0001**
Child seat/Seat belt vs No Protective Equipment	0.21 (0.14, 0.33)	**<.0001**
Protective Clothing/Helmet vs No Protective Equipment	1.19 (0.21, 6.89)	0.8471

Table 5: Model based adjusted OR (95% CI) based on multivariable logistic regression for discharge status

Variable	OR (95% CI)	p-value
Sex Female vs Male	0.40 (0.18, 0.88)	**0.0228**
Pediatric vs Adults	0.78 (0.23, 2.61)	0.6873
Hispanic vs non-Hispanic	0.64 (0.19, 2.15)	0.4754
Drug Use vs No Drug Use	2.25 (0.53, 9.61)	0.2736

Table 6: Model based adjusted RR (95% CI) based on quasi-Poisson regression for hospital LOS

Variable	RR (95% CI)	p-value
Sex Female vs Male	0.85 (0.69, 1.05)	0.1405
Pediatric vs Adults	0.53 (0.33, 0.86)	**0.0096**
Hispanic vs non-Hispanic	0.89 (0.54, 1.22)	0.3161
Drug Use vs No Drug Use	3.36 (2.65, 4.25)	**<.0001**
Child seat /Seat belt vs No Protective Equipment	0.43 (0.32, 0.53)	**<.0001**

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Ethics approval statements: This study received approval by the DHR Health Institute for Research and Development Institutional Review Board (protocol number 1574841-2 approved on 08/18/2020).

Contributions statement: HSE conceptualized the study, wrote the first manuscript draft, and supervised the overall project. ATR, KV, and GP extracted and analyzed the data. MGB, KV, and GP completed reviewer revisions and wrote final draft of the manuscript. All authors contributed to the editing and final version of the manuscript.

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Data Availability Statement: The data was extracted from a trauma registry at a regional trauma center from January 1, 2015 to August 31, 2020. The de-identified data is available upon reasonable request.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	8-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-10

		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.