Pediatric ATV Injuries in a Statewide Sample: 2004 to 2014

Mariano Garay, MD,[a] Joseph Hess, PhD,[b] Douglas Armstrong, MD,[c] William Hennrikus, MD[c]

abstract

OBJECTIVES: To establish the incidence, mortality rate, and fracture location of pediatric patients injured while using an all-terrain vehicle (ATV) over an 11-year period.

METHODS: A retrospective study using a state trauma database for patients ages 0 to 17 years who sustained injuries while using an ATV. Thirty-two pediatric and adult trauma centers within the state were evaluated from January 1, 2004, to December 31, 2014.

RESULTS: The inclusion criteria were met by 1912 patients. The estimated mean annual incidence during the period of the study was 6.2 patients per 100 000 children in the pediatric population <18 years of age. There was a decrease of 13.4% in the mean incidence when comparing the first 5 years of the study with the last 6 years. The median age of patients was 14 years. The median hospital length of stay and injury severity score were 3 days and 9, respectively. There were 28 fatalities (1.5%). The mean mortality incidence was 0.09 deaths per 100 000 children and remained relatively constant. The majority of patients (55.4%) sustained at least 1 bone fracture at or below the cervical spine. The femur and tibia were more commonly fractured (21.6% and 17.7% of the patients, respectively).

CONCLUSIONS: Despite current guidelines by the American Academy of Pediatrics, patients younger than 16 years of age remain victims of ATV injuries. Although there was a 13.4% reduction in the incidence of ATV-related injuries in recent years, continued preventive guidelines are still necessary to avert these injuries in children and adolescents.

FREE

[a]*College of Medicine, Pennsylvania State University, Hershey, Pennsylvania;* [b]*Division of Pediatric Surgery, Penn State Children's Hospital, Hershey, Pennsylvania; and* [c]*Department of Orthopaedic Surgery, Penn State Health Milton S. Hershey Medical Center, Hershey, Pennsylvania*

Dr Garay conceptualized and designed the study, conducted the statistical analyses, and drafted the initial manuscript; Drs Hennrikus and Armstrong conceptualized and designed the study, reviewed and revised the manuscript, and critically reviewed and edited the final manuscript as submitted; Dr Hess conceptualized and designed the study, obtained data from the Pennsylvania Trauma Systems Foundation, and revised the final manuscript as submitted; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

DOI: https://doi.org/10.1542/peds.2017-0945

Accepted for publication May 23, 2017

Address correspondence to William Hennrikus, MD, Penn State Milton S. Hershey Medical Center, College of Medicine, 30 Hope Dr, Building A, Hershey, PA 17033. E-mail: whennrikus@pennstatehealth.psu.edu

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

WHAT'S KNOWN ON THIS SUBJECT: All-terrain vehicle (ATV)-related crashes are a source of morbidity and mortality in children despite established guidelines by industry and medical organizations regarding their use. Estimates of the incidence of ATV-related injuries in children have shown a recent decrease.

WHAT THIS STUDY ADDS: A statewide database of pediatric patients admitted to trauma centers because of ATV crashes confirmed the recent decrease in the incidence, whereas mortality remained relatively constant. However, the incidence change was small and not clinically or statistically significant.

To cite: Garay M, Hess J, Armstrong D, et al. Pediatric ATV Injuries in a Statewide Sample: 2004 to 2014. *Pediatrics.* 2017;140(2):e20170945

All-terrain vehicle (ATV)-related crashes among children are not a novelty. Since the development of ATVs more than 4 decades ago, they have been a source of pediatric injuries and death.[1–6] Recognition of their injury potential prompted the establishment of guidelines regarding their use by government, industry, and medical organizations. In an effort to mitigate the incidence of ATV injuries in children, the American Academy of Pediatrics (AAP) established guidelines in 1987 regarding their use by children.[7] Because of a sharp increase in the number of injuries during the 1980s, a 10-year consent decree was enacted in 1988 to stop future sales and production of the 3-wheel ATVs in the United States, to restrict sales of adult-size ATVs to children 16 years and older, and to make available a rider safety training.[1,7–9] In their most recent policy statement in 2000, the AAP recommended that the use of ATVs be restricted to those >16 years of age, be restricted to off-road use only, and to disallow passengers.[7] States have also taken some of the ATV regulation burden. However, results have been mixed regarding the effects of state laws in the reduction of child mortality rates.[2,10–13] Still, from 1982 to 2015, the Consumer Product Safety Commission (CPSC) has estimated that 3613 (or 22%) of decedents because of ATV crashes were children <16 years of age.[14]

Multiple studies have been conducted by researchers who used the CPSC National Electronic Injury Surveillance System and the Healthcare Cost and Utilization Project to determine the incidence of ATV-related injuries in children and adolescents.[3,15–19] These studies are useful in demonstrating national trends but may be limited by their respective researchers' use of estimates from a sample population to make generalized conclusions. The trend observed by researchers in some studies is an increase in the incidence of children injured while using an ATV in the early 2000s, whereas researchers in more recent studies have concluded that there has been a decrease in the incidence of injuries at the end of that decade.[15,16,18–20] Researchers in other studies have evaluated the incidence of ATV-related injuries by using single-institution trauma databases, with mixed results.[5,20–22] Orthopedic injuries in children are reported to be common in ATV crashes and have been studied with different methodologies.[4–6,17–19,21–24] To our knowledge, no authors of recent studies have used a sample of patients admitted to multiple trauma centers within a state to establish the incidence, mortality trend, and anatomic distribution of fractures because of ATV usage in children and adolescents. More detailed fracture information will help practitioners prepare for and treat these injuries. We conducted a retrospective study by using our state trauma database to establish these parameters.

METHODS

This study was an institutional review board–exempt retrospective study using a statewide trauma database. We queried the Pennsylvania Trauma Systems Foundation (PTSF) and obtained data from 32 trauma centers within the state of Pennsylvania. The PTSF is the organization in charge of accrediting trauma centers within the state. Trauma centers are required to submit trauma information and maintain a trained registrar. The data are audited through an interrater reliability process.

The study period spanned from January 1, 2004, to December 31, 2014. Patients ages 0 to 17 years were included. Stratification was performed by age groups 0 to 5, 6 to 11, 12 to 15, and 16 to 17 years old. The stratification follows the CPSC data analysis, the AAP guidelines regarding the use of ATVs, and other ATV studies of children and adolescents.[7,14,15,25] E-codes and trauma narratives were used to assess ATV-related traumatic injuries within the PTSF database. E-codes 821, 821.1 to 821.4, and 821.8 to 821.9 were included and reviewed for accuracy. We then searched the database for the terms "ATV," "all-terrain vehicle," "quad," "four wheeler," and "three wheeler" as well as variants of these terms. The database provides information regarding location of the crash, such as a street or roadway.

We reviewed the initial sample for coding errors and non–ATV-related injuries by using the trauma narrative. Pedestrians and bystanders who were injured by an ATV were excluded. Dirt bikes and minibikes were also excluded from the study. A passenger of an ATV was labeled as such by codes and by evaluation of crash narratives. We also included in this group patients who were described as being pulled by an ATV on a trailer, sled, or snow tube. The database only assesses the index admission. However, to avoid duplication of injured patients because of transfers between trauma centers, we reviewed transfer codes within the database and compared dates of birth with injury dates. Terminal admissions were included in the analysis when these parameters were met. The discharge status was used to assess those who died during the admission. *International Classification of Diseases, Ninth Revision* codes were used to identify anatomic locations of fractures. Only fractures at or below the cervical spine were considered, and thus, facial and head fractures were excluded from the analysis. US census intercensal estimates were used to estimate the rate of incidence and mortality per 100 000 children in the population <18 years of age within the state of Pennsylvania.[26,27]

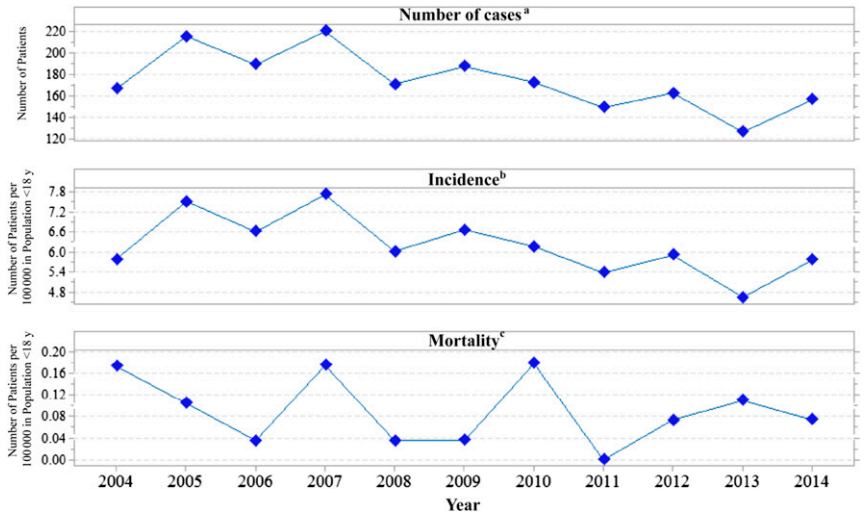

FIGURE 1

[a] Number of patients per year who sustained injuries because of ATV-related crashes within the state of Pennsylvania. [b,c] Number of patients per 100 000 children in the population <18 years of age. Population was estimated by the US census intercensal population within the state of Pennsylvania for children and adolescents.[26,27]

TABLE 1 Age Group (Years) Characteristics for Patients Injured While ATV Was in Use

	0–5 (*n* = 120)[a]	6–11 (*n* = 409)[a]	12–15 (*n* = 910)[a]	16–17 (*n* = 473)[a]	All (*n* = 1902)[b]	*P*[c]
Boys	81 (67.5)	279 (68.2)	688 (75.6)	376 (79.5)	1424 (74.5)	<.001
Girls	39 (32.5)	130 (31.8)	222 (24.4)	97 (20.5)	488 (25.5)	
Passenger or being pulled						
Yes	83 (69.2)	128 (31.3)	172 (18.9)	69 (14.6)	452 (23.6)	<.001
No	37 (30.8)	281 (68.7)	738 (81.1)	404 (85.4)	1460 (76.4)	
Helmet used						
Yes	46 (38.3)	213 (52.1)	475 (52.2)	198 (41.9)	932 (48.7)	<.001
No	74 (61.7)	196 (47.9)	435 (47.8)	275 (58.1)	980 (51.3)	
Admitted to ICU						
Yes	32 (26.7)	95 (23.2)	256 (28.1)	165 (34.9)	548 (28.7)	.002
No	88 (73.3)	314 (76.8)	654 (71.9)	308 (65.1)	1364 (71.3)	
Fracture						
Yes	50 (41.7)	202 (49.4)	533 (58.6)	275 (58.1)	1060 (55.4)	<.001
No	70 (58.3)	207 (50.6)	377 (41.4)	198 (41.9)	852 (44.6)	
Fatality						
Yes	4 (3.3)	5 (1.2)	16 (1.8)	3 (0.6)	28 (1.5)	.12
No	116 (96.7)	404 (98.8)	894 (98.2)	470 (99.4)	1884 (98.5)	

[a] Count and (%) within age group.

[b] Count and (%) of population.

[c] χ^2 test of association between age groups. Percent between age groups may not add to 100% because of rounding.

Data collection was performed by using Microsoft Excel 2010. Statistical analysis was performed by using Minitab version 17.3 (Minitab Inc, State College, PA). For continuous variables, skewedness, kurtosis, and Kolmogorov-Smirnov normality tests were performed. For normally distributed data, a 2-sample *t* test was used. For data that were not normally distributed, a Kruskal-Wallis test with Bonferonni correction for multiple comparisons between medians was performed at an α level of .05. For binary variables with a large sample, a χ^2 test was performed. A logistic regression was used to assess the odds ratio and 95% confidence intervals. All *P* values were deemed statistically significant at <.05.

RESULTS

A total of 1912 patients met the inclusion criteria of our study. The median number of patients per year was 170 (range: 126–220 patients) (Fig 1). Sixty-seven percent of the crashes happened between May and September. The estimated mean annual incidence from 2004 to 2014 was 6.2 cases per 100 000 children (Fig 1). There was a 13.4% decrease in the mean incidence when comparing the first 5 years of the study with the last 6 years (6.7 per 100 000 children to 5.8 per 100 000 children, respectively, *P* = .08). The mean mortality incidence from 2004 to 2014 was 0.09 deaths per 100 000 children (Fig 1). The median age of patients was 14 years (range: 1–17 years). Boys accounted for 74.5% of the patients. Being a passenger or being pulled accounted for 23.6% of the injured patients within the cohort (Table 1). A street or roadway was identified as the location of the crash in 15.4% of the cases. A helmet was reported to have been used by 48.7% of the patients (Table 1). A trauma alert or a trauma consult was activated in 87% of the cases. In 58% of the crashes in which a trauma was activated, the level of the trauma activation was available. Of those, level 1 and level 2 traumas accounted for 12% and 57% of the cases, respectively.

The median hospital length of stay (LOS) of all patients was 3 days (range: 0–58 days). When comparing the LOS differences between age groups, those aged 16 to 17 years (median of 3, range of 0–39 days) and 12 to 15 years (median of 3, range of 0–58 days) had a longer LOS than those who were 0 to 5 years of age (median of 2, range of 0–34 days), a difference of 1 day and *P* < .001. There were 548 patients who were admitted to the ICU (28.7%) (Table 1). The median ICU LOS of those who were admitted to the ICU was 2 days (range: 1–54 days). The

TABLE 2 Fracture Locations and Characteristics by Age Group (Years)

	0–5 (*n* = 120)[a]	6–11 (*n* = 409)[a]	12–15 (*n* = 910)[a]	16–17 (*n* = 473)[a]	All (*n* = 1912)[b], [*n* = 1060][c]	*P*[d]
Cervical spine	0 (0)	2 (0.5)	21 (2.3)	22 (4.7)	45 (2.4), [4.3]	<.001
Thoracolumbar spine	1 (0.8)	10 (2.4)	79 (8.7)	70 (14.8)	160 (8.4), [15.1]	<.001
Sternum or ribs	4 (3.3)	19 (4.7)	67 (7.4)	58 (12.3)	148 (7.7), [14]	<.001
Clavicle or scapula	3 (2.5)	14 (3.4)	68 (7.5)	42 (8.9)	127 (6.6), [12]	.002
Humerus	18 (15)	43 (10.5)	60 (6.6)	10 (2.1)	131 (6.9), [12.4]	<.001
Radius or ulna	2 (1.7)	30 (7.3)	94 (10.3)	34 (7.2)	160 (8.4), [15.1]	.005
Wrist	0 (0)	0 (0)	9 (1)	3 (0.6)	12 (0.6), [1.1]	[e]
Hand	2 (1.7)	11 (2.7)	27 (3)	20 (4.2)	60 (3.1), [5.7]	.38
Pelvis or sacrum	2 (1.7)	17 (4.2)	70 (7.7)	47 (10)	136 (7.1), [12.8]	.001
Femur	14 (11.7)	61 (14.9)	111 (12.2)	43 (9.1)	229 (12), [21.6]	.07
Patella	0 (0)	4 (1)	7 (0.8)	4 (0.9)	15 (0.8), [1.4]	[e]
Tibia or fibula	6 (5)	27 (6.6)	114 (12.5)	41 (8.7)	188 (9.8), [17.7]	.001
Ankle	1 (0.8)	7 (1.7)	35 (3.9)	20 (4.2)	63 (3.3), [5.9]	.05
Foot	2 (1.7)	3 (0.7)	22 (2.4)	9 (1.9)	36 (1.9), [3.4]	.23
Open fracture	4 (3.3)	36 (8.8)	93 (10.2)	31 (6.6)	164 (8.6), [15.5]	.02
Extremity fracture	42 (35)	163 (39.9)	374 (41.1)	150 (31.7)	729 (38.1), [68.8]	.005

[a] Count and (%) within age group.
[b] Count and (%) of population.
[c] [% of all fractures].
[d] χ^2 test of association between age groups.
[e] Group size too small for χ^2 analysis.

TABLE 3 Logistic Regression Analysis of Fractures

	Fracture		Odds Ratio (95% Confidence Interval)	*P*[a]
	Yes	No		
Age, y				<.001
0–5	50 (41.7)	70 (58.3)	Reference	
6–11	202 (49.4)	207 (50.6)	1.37 (0.91–2.06)	
12–15	533 (58.6)	377 (41.4)	1.98 (1.35–2.91)	
16–17	275 (58.1)	198 (41.9)	1.94 (1.30–2.92)	
Sex				.081
Boy	806 (56.6)	618 (43.4)	Reference	
Girl	254 (52.1)	234 (47.9)	0.83 (0.68–1.02)	
Passenger				.001
Yes	219 (48.5)	233 (51.5)	0.69 (0.56–0.85)	
No	841 (57.6)	619 (42.4)	Reference	
Total	1060 (55.4)	852 (44.6)		

Odds ratio (95% confidence interval) between age groups, sex, and passenger status of patients injured while ATV was in use.
[a] Unadjusted logistic regression.

median injury severity score for all patients was 9 (range: 1–59). Age group comparison showed increased injury severity scores in those aged 16 to 17 years (median of 5, range of 1–59) and those aged 12 to 15 years (median of 5, range of 1–50) when compared with children aged 0 to 5 years (median of 4, range of 1–45), a difference of 1 and $P < .001$.

Although the cause of death was not specified within the data set, 28 patients (1.5%) died during the initial admission after an ATV crash (Table 1). Of the deceased children, 28.6% were reported to have been wearing a helmet. The majority of children who died (57.1%) were 12 to 15 years old. Of the decedents, 7 were passengers and 9 were injured while the ATV was being used on a street or roadway. Neither sex nor age group was associated with mortality ($P = .17$ and .12, respectively). Similarly, being a passenger or being pulled was not associated with mortality ($P = .87$). Helmet use was associated with a reduction in the number of deaths, whereas riding on a street or roadway was associated with more deaths ($P = .031$ and .026, respectively).

The majority of the patients sustained at least 1 bone fracture below the level of the cervical spine (55.4%) (Table 2). The rate of fracture was higher on the femur and tibia, with 21.6% and 17.7% of the total fractures, respectively. Open fractures were sustained by 15.5% of the patients with fractures. Long bones of the extremities, as well as the bones of the wrist, hand, and foot, were fractured more often (68.8%) than those of the axial skeleton, clavicle or scapula, and pelvis or sacrum combined (31.2%) (Table 2). Children aged 16 to 17 and 12 to 15 years were more likely than those aged 0 to 5 years to sustain a fracture (odds ratio of 1.94 and 1.98, respectively; $P < .001$) (Table 3).

DISCUSSION

During the 11-year study period, the median number of patients who were admitted to a trauma center within our state because of ATV-related injuries was 170 patients per year. We observed a 13.4% decrease in the incidence of patients admitted when comparing the first 5 years of the study with the last 6 years, and it was not statistically or clinically significant. We did not evaluate and therefore cannot state reasons for

the observed decreased incidence in ATV-related injuries within our state. Authors of previous studies have evaluated the national incidence of ATV-related injuries in children by using different methodologies, which are worth mentioning.[3,15–19] Bowman and Aitken[16] conducted a retrospective study using the Kids' Inpatient Database of the Healthcare Cost and Utilization Project to estimate the incidence of patients injured from 1997 to 2006. They found an upward trend in the incidence of patients admitted because of ATV-related crashes that peaked in 2006, and they attributed the trend to the expiration of the ATV consent decree in 1998. Interestingly, they noted that the Northeast region of the United States saw a stagnant incidence rate that ranged from 3.9 to 3.7 per 100 000 patients from 2000 to 2006.[16] In a retrospective study, Shults et al[18] in 2013 used the CPSC National Electronic Injury Surveillance System-All Injury Program to estimate the annual injury incidence because of ATVs in children 15 years of age and younger from 2001 to 2010. They also noted an increased rate of injuries that peaked in 2004 and then decreased 37% during the last 6 years of their study period. They speculated that, perhaps, the reduction in incidence was attributed to a declining economy in which discretionary spending by consumers was reduced, and thus, ATV ridership and new purchases for the younger age groups may have been reduced.[18] Williams et al[28] evaluated on-road ATV deaths for all ages by using the Fatality Analysis Reporting System and noted a decline in mortality of 19% between 2008 and 2011. They correlated their findings with a decline in motor vehicle crash deaths and also speculated that a decline in the US economy in early 2008 may have been responsible.[28] It is important to note that, historically, motor vehicle crash mortality declines were also seen during the economic recession in the early 1980s and 1990s.[29] However, we are unaware of studies in which researchers evaluated ATV injury incidence in children during those periods to ascertain the influence of the economy.

There were 28 (1.5%) fatalities during our study period. The median mortality rate was 0.07 per 100 000 children between 2004 and 2014 and remained relatively steady throughout the 11-year period. In 2005, Killingsworth et al,[3] by using unweighted data from the Kids' Inpatient Database, estimated that the mortality rate within their sample in 1997 and 2000 for children <18 years and whose deaths were attributed to ATV crashes was 0.9%. We found that those aged 12 to 15 years had the largest proportion of deaths within our study. The findings are similar to those by Denning et al,[15] who in 2014 conducted a retrospective study using data from the CPSC and also found that those aged 12 to 15 years had the largest proportion of deaths among children resulting from ATV crashes.

The causes of death as a result of ATV use in children have been retrospectively studied, and it has been concluded that being a passenger or using an ATV on paved roads, especially among adolescents, increases the mortality rate.[10,11,15,25] We found that despite the dangers of carrying a passenger and riding on the roads, 23.6% of the children in our cohort were either passengers or were being pulled at the time of injury, whereas another 15.4% were injured while the ATV was being used on a street or roadway, both of which showed a significant association with mortality. Current Pennsylvania laws restrict ATV operation by those <8 years of age on state lands, and helmets are mandatory for all ages. Between the ages of 8 and 16 years, operators should have attended safety training and possess a training certificate to operate on state lands, but they are not restricted from operating an ATV on the land of their parents or guardians.[30] Researchers in numerous studies as well as professional organizations and ATV manufacturers have concluded that children <16 years of age do not have the capacity to safely operate ATVs.[7,8,22,31,32] Still, the law within our state allows for children to be exposed to the dangers of ATVs before 16 years of age. Although the data from previous studies are inconclusive about the effectiveness of regulations, some reductions in the rates of injury have been observed in states with more stringent regulations.[2,10–13] In addition to the enforcement of current laws, states should consider amendments that reflect the findings established by multiple research studies about the dangers of ATV use by children and the devastating consequences.

Orthopedic injuries are among the most prevalent types of injuries from ATV-related crashes in children. We found that 55% of our cohort sustained a fracture at or below the cervical spine. This finding is similar to many previous studies in which researchers evaluated fractures related to ATV use.[4–6,21,22] Most recently, in 2016, Shannon et al[21] conducted a 19-year, single-institution retrospective study in which they compared ATV-, dirt bike-, and snowmobile-related fracture rates with anatomic location. They found lower-extremity bones were commonly fractured (31%) in ATV-related crashes in children. We found that 21.6% of the patients who sustained a fracture sustained it at the femur, whereas 17.7% sustained fractures either at the tibia or fibula. Our findings are similar to those by Shah et al,[24] who evaluated >500 patients' radiographs for injuries sustained while an ATV was in use and also concluded that the femur and tibia were the most commonly fractured bones. Within our cohort, 15.5% (164 of 1060) of the patients sustained open fractures,

demonstrating the large kinetic energy transferred to patients during the crash. We had aimed to construct a multivariate logistic regression model to better predict factors associated with fractures in children because of ATV injuries. However, data were incomplete regarding the speed and size of the ATV at the time of injury. We believe that limited our estimation of the kinetic energy required for patients to sustain fractures, an important regressor in determining fracture etiology. Researchers conducting prospective studies and those who maintain trauma databases should consider adding speed of travel at the time of injury as well as vehicle engine size to their data collection items in an effort to better understand the factors associated with ATV-related fractures in children.

The current study has limitations. The retrospective nature of a trauma database analysis means it is exposed to selection bias because it is likely that patients admitted to trauma centers were more severely injured than those who did not receive medical attention at a registered trauma center. For the same reason, mortality numbers are likely higher than the ones we estimated in this study because some patients may have never reached a trauma center before their death. Large databases are also susceptible to coding errors, omissions, and duplications. However, it is important to note that the PTSF uses interrater reliability, with audits from both the submitting trauma center as well as the PTSF, during accreditation visits. In addition, we did not distinguish or search for roll bars or seat belts to differentiate side-by-side utility vehicles and recreational off-road vehicles from ATVs. Because the study is limited to the state of Pennsylvania, national estimates may differ because we observed changes in injury rates throughout the year. Thus, comparative analysis may be limited to states with similar topography, climate, and laws pertaining to ATV use by children.

CONCLUSIONS

Although we observed a decrease in the incidence of injuries during the last 6 years of our study period, the difference was <1 patient per 100 000 children in the population <18 years of age, which was not clinically or statistically significant. We advise primary care providers to be the forefront of the prevention effort and to continue to provide families with safety information and recommendations of age restrictions for ATV use by children.

ACKNOWLEDGMENTS

We thank the PTSF (Mechanicsburg, PA) for providing the data for the study. The Pennsylvania Trauma Outcome Study was the source of data. The PTSF disclaims responsibility for any analyses, interpretations, or conclusions.

ABBREVIATIONS

AAP: American Academy of Pediatrics
ATV: all-terrain vehicle
CPSC: Consumer Product Safety Commission
LOS: length of stay
PTSF: Pennsylvania Trauma Systems Foundation

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

REFERENCES

1. Lynch JM, Gardner MJ, Worsey J. The continuing problem of all-terrain vehicle injuries in children. *J Pediatr Surg*. 1998;33(2):329–332
2. Keenan HT, Bratton SL. All-terrain vehicle legislation for children: a comparison of a state with and a state without a helmet law. *Pediatrics*. 2004;113(4). Available at: www.pediatrics.org/cgi/content/full/113/4/e330
3. Killingsworth JB, Tilford JM, Parker JG, Graham JJ, Dick RM, Aitken ME. National hospitalization impact of pediatric all-terrain vehicle injuries. *Pediatrics*. 2005;115(3). Available at: www.pediatrics.org/cgi/content/full/115/3/e316
4. Kellum E, Creek A, Dawkins R, Bernard M, Sawyer JR. Age-related patterns of injury in children involved in all-terrain vehicle accidents. *J Pediatr Orthop*. 2008;28(8):854–858
5. Kelleher CM, Metze SL, Dillon PA, Mychaliska GB, Keshen TH, Foglia RP. Unsafe at any speed–kids riding all-terrain vehicles. *J Pediatr Surg*. 2005;40(6):929–934, discussion 934–935
6. Kirkpatrick R, Puffinbarger W, Sullivan JA. All-terrain vehicle injuries in children. *J Pediatr Orthop*. 2007;27(7):725–728
7. American Academy of Pediatrics; Committee on Injury and Poison Prevention. All-terrain vehicle injury prevention: two-, three-, and four-wheeled unlicensed motor vehicles. *Pediatrics*. 2000;105(6):1352–1354
8. Dolan MA, Knapp JF, Andres J. Three-wheel and four-wheel all-terrain vehicle injuries in children. *Pediatrics*. 1989;84(4):694–698
9. Weintraub R, Best M. ATVs on roadways: a safety crisis. Report by the Consumer Federation of America. 2014. Available at: http://consumerfed.org/wp-content/uploads/2010/08/ATVs-on-roadways-03-2014.pdf. Accessed March 7, 2017
10. McBride AS, Cline DM, Neiberg RH, Westmoreland KD. Pediatric all-terrain

vehicle injuries: does legislation make a dent? *Pediatr Emerg Care*. 2011;27(2):97–101

11. Upperman JS, Shultz B, Gaines BA, et al. All-terrain vehicle rules and regulations: impact on pediatric mortality. *J Pediatr Surg*. 2003;38(9):1284–1286
12. Helmkamp JC. A comparison of state-specific all-terrain vehicle-related death rates, 1990-1999. *Am J Public Health*. 2001;91(11):1792–1795
13. Helmkamp JC, Aitken ME, Graham J, Campbell CR. State-specific ATV-related fatality rates: an update in the new millennium. *Public Health Rep*. 2012;127(4):364–374
14. Consumer Product Safety Commission. 2015 Annual report of ATV-related deaths and injuries. 2017. Available at: https://www.cpsc.gov/s3fs-public/atv_annualReport2015.pdf. Accessed February 4, 2017
15. Denning GM, Harland KK, Jennissen CA. Age-based risk factors for pediatric ATV-related fatalities. *Pediatrics*. 2014;134(6):1094–1102
16. Bowman SM, Aitken ME. Still unsafe, still in use: ongoing epidemic of all-terrain vehicle injury hospitalizations among children. *J Trauma*. 2010;69(6):1344–1349
17. Shults RA, Wiles SD, Vajani M, Helmkamp JC. All-terrain vehicle-related nonfatal injuries among young riders: United States, 2001-2003. *Pediatrics*. 2005;116(5). Available at: www.pediatrics.org/cgi/content/full/116/5/e608
18. Shults RA, West BA, Rudd RA, Helmkamp JC. All-terrain vehicle-related nonfatal injuries among young riders in the United States, 2001-2010. *Pediatrics*. 2013;132(2):282–289
19. Sawyer JR, Bernard MS, Schroeder RJ, Kelly DM, Warnersurname WC Jr. Trends in all-terrain vehicle-related spinal injuries in children and adolescents. *J Pediatr Orthop*. 2011;31(6):623–627
20. Blecker N, Rhee P, Judkins DG, et al. Pediatric all-terrain vehicle trauma: the epidemic continues unabated. *Pediatr Emerg Care*. 2012;28(5):443–447
21. Shannon SF, Hernandez NM, Sems SA, Larson AN, Milbrandt TA. Pediatric orthopaedic trauma and associated injuries of snowmobile, ATV, and dirtbike accidents: a 19-year experience at a level 1 pediatric trauma center [published online ahead of print July 20, 2016]. *J Pediatr Orthop*. doi:10.1097/BPO.0000000000000838
22. Kute B, Nyland JA, Roberts CS, Hartwick-Barnes V. Recreational all-terrain vehicle injuries among children: an 11-year review of a Central Kentucky level I pediatric trauma center database. *J Pediatr Orthop*. 2007;27(8):851–855
23. Sawyer JR, Beebe M, Creek AT, Yantis M, Kelly DM, Warner WC Jr. Age-related patterns of spine injury in children involved in all-terrain vehicle accidents. *J Pediatr Orthop*. 2012;32(5):435–439
24. Shah CC, Ramakrishnaiah RH, Bhutta ST, Parnell-Beasley DN, Greenberg BS. Imaging findings in 512 children following all-terrain vehicle injuries. *Pediatr Radiol*. 2009;39(7):677–684
25. Denning GM, Harland KK, Ellis DG, Jennissen CA. More fatal all-terrain vehicle crashes occur on the roadway than off: increased risk-taking characterises roadway fatalities. *Inj Prev*. 2013;19(4):250–256
26. United States Census Bureau. Intercensal estimates of the resident population by sex and age for states: April 1, 2000 to July 1, 2010. Available at: www.census.gov/data/tables/time-series/demo/popest/intercensal-2000-2010-state.html. Accessed February 17, 2017
27. United States Census Bureau. American FactFinder: annual estimates of the resident population for selected age groups by sex for the United States, states, counties, and Puerto Rico commonwealth and municipios: April 1, 2010 to July 1, 2014. Available at: http://factfinder.census.gov/bkmk/table/1.0/en/PEP/2014/PEPAGESEX. Accessed November 15, 2016
28. Williams AF, Oesch SL, McCartt AT, Teoh ER, Sims LB. On-road all-terrain vehicle (ATV) fatalities in the United States. *J Safety Res*. 2014;50:117–123
29. Longthorne A, Subramanian R, Chen CL. An analysis of the significant decline in motor vehicle traffic fatalities in 2008. 2010. Available at: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811346. Accessed March 5, 2017
30. Commonwealth of Pennsylvania, Department of Conservation and Natural Resources. Summary of Pennsylvania's all-terrain vehicle law. Available at: www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_20030015.pdf. Accessed April 1, 2016
31. American Academy of Orthopaedic Surgeons. All-terrain vehicles position statement. Available at: www.aaos.org/uploadedFiles/PreProduction/About/Opinion_Statements/position/1101 - All Terrain Vehicles.pdf. Accessed March 6, 2017
32. Stevens WS, Rodgers BM, Newman BM. Pediatric trauma associated with all-terrain vehicles. *J Pediatr*. 1986;109(1):25–29

Pediatric ATV Injuries in a Statewide Sample: 2004 to 2014

Mariano Garay, Joseph Hess, Douglas Armstrong and William Hennrikus

Pediatrics 2017;140;
DOI: 10.1542/peds.2017-0945 originally published online July 17, 2017;

PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Pediatric ATV Injuries in a Statewide Sample: 2004 to 2014

Mariano Garay, Joseph Hess, Douglas Armstrong and William Hennrikus

Pediatrics 2017;140;
DOI: 10.1542/peds.2017-0945 originally published online July 17, 2017;