

All-Terrain Vehicle Legislation for Children: A Comparison of a State With and a State Without a Helmet Law

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ABSTRACT. *Background.* All-terrain vehicles (ATVs) continue to be a source of morbidity and mortality in the pediatric population despite recommendations from the American Academy of Pediatrics that children <16 years old not ride in or drive ATVs. ATV injuries have increased significantly in both children and adults most years since 1997.

Objective. To assess the effectiveness of ATV regulations for children on serious injuries by comparing ATV-related admissions to level I and II trauma hospitals in a state with and a state without ATV regulations.

Design. Ecologic study.

Patients. Children <16 years old who died and/or were treated in the trauma system of Pennsylvania or North Carolina after ATV crashes.

Outcome Measures. Injury types and cause of death were examined for all children. Comparisons were made by state (Pennsylvania [regulated] and North Carolina [unregulated]) for patterns of injury, place of injury, helmet use, and death.

Results. There were 1080 children identified in the trauma registries between January 1997 and July 2000. Forty-four percent required intensive care. Head injuries were the primary cause of death (45.7%). Fewer North Carolina children than Pennsylvania children (16.7% vs 35.8%) wore helmets, and they were more likely to be <11 years old (35.1% vs 27.8%). Living in North Carolina was an independent predictor for not wearing a helmet.

Conclusions. Living in Pennsylvania was associated with decreased risk factors for ATV injury such as young age and riding unhelmeted. However, despite regulations, many children suffered serious morbidity and mortality. These data support the recommendation that children <16 years old should be prohibited from riding or driving ATVs. *Pediatrics* 2004;113:e330–e334. URL: <http://www.pediatrics.org/cgi/content/full/113/4/e330>; all-terrain vehicles, pediatrics, injury, helmet use.

ABBREVIATIONS. ATV, all-terrain vehicle; CPSC, US Consumer Product Safety Commission; EMS, emergency medical service; OCME, Office of the Chief Medical Examiner; ED, emergency department; E, external cause of injury; GCS, Glasgow Coma Score; ICD-9-CM, *International Classification of Diseases, Ninth Revision, Clinical Modification*; df, degrees of freedom; OR, odds ratio; CI, confidence interval.

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Children riding all-terrain vehicles (ATVs) continue to suffer preventable injuries. The American Academy of Pediatrics has released guidelines recommending that children <16 years old not be allowed to operate off-road vehicles.¹ ATVs are unstable vehicles with a high center of gravity and can sustain speeds of 30 to 50 mph, making them especially unsafe for children.² Although the sale of new 3-wheeled ATVs was banned in 1988, there are currently no national regulations regarding the use of 4-wheeled ATVs, nor are there any restrictions on the drivers' age.³ In 2002, children <16 years old made up 33% of the total ATV reported deaths to the US Consumer Product Safety Commission (CPSC), with children <12 years old accounting for 10% of total deaths.⁴ The estimated injury rate for children <16 years old in 1 state was 3.4 per 100 registered ATVs.⁵

ATV crash injuries that most commonly require medical care are orthopedic, head, and facial injuries.⁶ Severe closed head injuries and paraplegia after ATV crashes have been reported.⁷ Statistical models using the National Electronic Injury Surveillance System estimate that helmet use for all riders might reduce the risk of death by 42% and the risk of nonfatal head injury by 64%.⁸ One study examining population-based ATV fatalities found that states with no ATV safety legislation had a fatality rate of 0.17 per 100 000 persons, compared with 0.08 deaths per 100 000 persons in states with helmet and other safety requirements.⁹ For these reasons, some states (including Pennsylvania) have enacted helmet laws and restricted driving or riding ATVs for children <16 years old.⁹ Pennsylvania does not allow children <10 years old to ride ATVs on public lands or recreation areas and requires both a training certificate and a helmet that meets motorcycle specifications for children <16 years old.¹⁰ Other states (including North Carolina) have no such restrictions.

This study examines patterns of injury and fatalities in children <16 years old identified through the Pennsylvania Trauma Database and fatality reports for Pennsylvania from the CPSC, death certificate data, and emergency medical service (EMS) data. It compares the same data gathered in North Carolina through the North Carolina Trauma Registry and the Office of the Chief Medical Examiner (OCME). Pennsylvania and North Carolina were chosen as study sites because of the availability of their trauma registries and because Pennsylvania has long-standing ATV legislation, whereas North Carolina has no

ATV legislation. We attempt to 1) determine whether the pattern of injuries (place of injury, age at time of injury, and helmet use) treated by trauma centers is consistent with ATV regulations when comparing a state with and without ATV regulations and (2) describe the types of injury that cause morbidity leading to trauma-center admission or mortality among young ATV riders and drivers.

METHODS

Experimental Design

This study is an ecologic study using data from 2 state trauma registries (North Carolina and Pennsylvania) as well as all ATV-related deaths in both states from January 1997 to July 2000. Additionally, data from the trauma registries and all deaths were analyzed as a case series to examine types of injury and cause of death among children identified as having suffered an ATV-related injury.

Subject Ascertainment

Pennsylvania

All children <16 years old who were injured in an ATV crash were identified via the Pennsylvania State Trauma Registry. Included in the trauma registry are patients admitted to a level I or II trauma center for ≥ 48 hours, those who died in the emergency department (ED) of the trauma center, those who were transferred to a level I or II trauma center from another facility for ongoing care, and those who died from a trauma-related incident. Patients were identified both by external cause of injury (E) code (E codes 821.0, 821.1, 821.8, and 821.9) and search of the descriptive field in the Registry for ATVs. The Pennsylvania State Trauma Registry reabstracts a minimum of 10% of the charts included in the registry each year to check for accuracy of information.

Data obtained from the trauma registry included the following types of information: age, gender, and race; information on helmet use; injury severity scores¹¹ and Glasgow Coma Scores (GCSs);¹² and types of injury, hospital and intensive care unit length of stay, and outcome. Deaths were reviewed both from the trauma registry and the CPSC databases. The CPSC is a federal agency created in 1973 to collect and disseminate statistics and information relating to death and injury associated with consumer products. It maintains a death certificate file through state health departments and an incident file, which contains summaries of events from data gathered through reports from medical examiners, newspaper accounts, crash investigations, and letters to the CPSC (www.cpsc.gov). Data are available for both national and state-specific fatalities for specific products with a description of the incident. In some cases, it was not possible to determine whether the same deaths were referred to by both databases. Therefore, only cases that were classified by the CPSC as dead on arrival and were clearly not in the trauma registry (no match for age, gender, and injury type) were counted as additional deaths. In addition, to ensure that all deaths in Pennsylvania were included, state hospital discharge data were examined by trauma-center status. There were no deaths recorded from nontrauma centers under E codes 821.0, 821.1, 821.8, or 821.9. EMS data also were reviewed for prehospital deaths. The EMS data contain a field for recreational vehicle and age.

North Carolina

The North Carolina State Trauma Registry collects data from the state's designated trauma centers and 13 additional hospitals. It includes all patients admitted to a hospital for ≥ 24 hours from an ED, who die in the ED, who are dead on arrival, who require operative management, and who are transferred from another hospital for ongoing trauma care. It currently does not verify registry records against paper charts. The registry was queried for E codes specific to ATV injuries (821.0, 821.1, 821.8, and 821.9), limited to level I and level II trauma centers. Because the North Carolina Trauma Registry does not have a specific field for ATV crashes, the registry was queried also for all E codes used in the identification of an ATV crash from the Pennsylvania State Trauma Registry (813.0, 816.0, 816.1, 816.8, 819.0, 819.1, 823.0,

823.1, 825.0, and 825.1). These charts were reviewed by H.T.K. or a trained pediatric intensive care unit nurse on a standardized data abstraction form to ascertain whether they were ATV crashes. In addition, charts in which helmet use was undocumented were reviewed for helmet use. Ten percent of charts were reviewed for accuracy by 1 of the authors (H.T.K.) or the institution-specific trauma registrar to ensure that data collected from the 2 registries were similar in quality. The North Carolina Trauma Registry collects information on demographics, protective devices, injury characteristics, and hospital outcomes similar to the Pennsylvania State Trauma Registry.

North Carolina has an OCME through which all deaths are recorded. Files are created for each death including age, gender, circumstances of death, safety-device use, and an autopsy report (if 1 was performed). This database was searched for all ATV-related deaths, and each file identified was reviewed by 1 of the authors (H.T.K.) for place of death, manner of death, and helmet use. In this way patients who were declared dead in the field and not brought to a hospital or who died at a nontrauma-center hospital were identified.

Exposure

The exposure in this study is living in Pennsylvania. The law in Pennsylvania prohibits the use of ATVs by children <10 years old on public land and requires that children <16 years old riding on public land be helmeted and pass an ATV safety course.¹⁰ In addition, all persons riding ATVs must wear a helmet meeting the specification for motorcycle riders.¹³ Pennsylvania has had ATV regulations in place since 1985. The comparison state, North Carolina, has no ATV legislation.

Definitions

Patients were coded for primary cause of injury by using *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) code.¹⁴ Patients were classified as head injured if they sustained loss of consciousness, concussion, skull fracture, cerebral contusion or laceration, or had an intracranial hemorrhage (subdural, subarachnoid, or epidural). The ICD-9-CM codes 800.00–801.99, 803.00–804.9, and 850.00–854.1 were used. Other injuries were classified into facial (including scalp, eyes, ears, facial bones, and lacerations and contusions defined by ICD-9-CM codes 802.0–802.8, 870.0–873.9, 920, and 921.0–921.9), spinal cord/neck/vertebral, abdominal or pelvic, thoracic, extremity, vascular, burn, and peripheral nerve injuries.

Cause of death was classified by the first ICD-9-CM code from the trauma registry. The second and third ICD-9-CM codes were reviewed for all patients who died to ensure that all contributing factors to the patients' deaths were considered. Four deaths found through the CPSC, which were not in the Pennsylvania Trauma Registry, did not have a cause of death specified. Two children identified by the CPSC were thrown from ATVs onto train tracks and struck by a train. These 2 deaths were coded as multiple injuries.

Statistical Analysis

The data were examined for demographic and injury characteristics by using frequencies and percentages. Medians with 25th and 75th percentiles were calculated for length of stay, because the data were not distributed normally. The distribution of missing values of helmet use was examined by state, age, and type of injury to check for ascertainment bias. States were compared for percent helmet use, place of injury, and age and gender of child injured by using the χ^2 statistic. Finally, a logistic regression model including age (coded as an indicator variable), state, and gender was constructed to examine predictors of helmet use among children in the trauma database.

Human Subjects

This study was approved by the Institutional Review Board at the University of North Carolina Hill Medical School (Chapel Hill, NC). Additionally, review of charts was approved at the Institutional Review Boards of Carolinas Health Care System, East Carolina University, Duke University Medical Center, and Wake Forest University-Baptist Medical Center.

TABLE 1. Demographic Features of Children Involved in ATV Crashes in Pennsylvania and North Carolina Admitted to a Level I or II Trauma Center

	Pennsylvania		North Carolina	
	<i>n</i>	%	<i>n</i>	%
Age groups, y*				
0–5	63	7.3	30	13.5
6–10	176	20.5	48	21.6
11–13	262	30.5	77	34.7
14–15	357	41.6	67	30.2
Gender*				
Male	726	84.6	149	67.1
Helmet use*				
Yes	307	35.8	37	16.7
No	358	41.7	132	59.5
Undocumented	193	22.5	53	23.9

* Significant difference in χ^2 test at ≤ 0.05 level.

RESULTS

There were 1080 children <16 years old identified as injured in an ATV crash in the entire case series. There were 858 children (79.4%) admitted to trauma centers in Pennsylvania and 222 (20.6%) admitted to trauma centers in North Carolina. Males comprised 81.0% (875) of the injured children. Of the 1080 children, the helmet status was known for 77.2% (834), and 344 (31.9%) of these children wore a helmet. Most children were injured while riding the ATV on the street or highway (31.6%) or in the woods, forest, or mountains (21.4%), with the rest injured in a variety of different locations. There were only 18 (1.7%) injuries on farms, 84 (7.8%) at home, and 120 (11.1%) in public parks. Twenty-six percent of the cohort did not have their place of injury specified.

Comparison of North Carolina and Pennsylvania

Demographics differed between the 2 states (Table 1). There was a higher proportion of girls than boys (32.9% vs 15.4%, respectively; $\chi^2 = 35.1$; degrees of freedom [df] = 1; $P < .01$) in North Carolina versus Pennsylvania. Helmet use was less common in North Carolina than Pennsylvania (16.7% vs 35.8%, respec-

tively; $\chi^2 = 32.8$; df = 1; $P < .001$), and there were more North Carolina children <11 years old than Pennsylvania children (35.1% vs 27.8%, respectively; $\chi^2 = 4.5$; df = 1; $P = .03$). The largest proportion of injuries in both states occurred on a street or highway (30.8% in Pennsylvania and 34.7% in North Carolina). However, 28.8% of the North Carolina children were injured in designated recreation areas, compared with 6.5% ($\chi^2 = 88.8$; df = 1; $P < .001$) of injured Pennsylvania children.

The cases with known helmet status from the trauma databases (843 children) were examined. There was no ascertainment bias for helmet use between states (22.5% unknown in Pennsylvania vs 23.9% unknown in North Carolina; $\chi^2 = 0.2$; df = 1; $P = .7$) or in children with brain injuries (21.5% unknown in children with brain injury vs 23.3% unknown in patients without brain injury; $\chi^2 = 0.4$; df = 1; $P = .5$); however, children <6 years old were less likely to have their helmet use ascertained, compared with older children (32.3% undocumented vs 21.9% undocumented, respectively; $\chi^2 = 5.2$; df = 1; $P = .02$). Within the subgroup of children with known helmet status, 36 (4.5%) who used a helmet had a GCS ≤ 8 , compared with 94 (11.8%) children without helmet use ($\chi^2 = 12.8$; df = 1; $P < .001$). A multivariate logistic regression model that included age, state, and gender was constructed to predict lack of helmet use. Girls (odds ratio [OR]: 1.9; 95% confidence interval [CI]: 1.3, 2.8), children ≤ 5 years old compared with children ≥ 14 years old (OR: 2.4; 95% CI: 1.2, 4.6), and North Carolina residents (OR: 2.7; 95% CI: 1.8, 4.0) were less likely to wear helmets.

Clinical Characteristics

Clinical characteristics of the children are shown in Table 2. All children were admitted to a hospital unless they were declared dead in the ED. A total of 479 children (44.4%) required admission to the intensive care unit for a median stay of 2 days.^{1,4} There were 171 (15.8%) children with severe head injury as

TABLE 2. Clinical Characteristics of Children Involved in ATV Crashes From Pennsylvania and North Carolina (*n* = 1080) Admitted to a Level I or II Trauma Center

	Pennsylvania (<i>n</i> = 858)		North Carolina (<i>n</i> = 222)	
	<i>n</i>	%	<i>n</i>	%
GCS				
3–8 (severe)	135	15.7	36	16.2
9–12 (moderate)	29	3.4	4	1.8
13–15 (mild)	673	78.4	140	63.1
Undocumented	21	2.4	42	18.9
Injury severity score				
<5	219	25.7	90	40.5
6–10	261	30.4	56	25.3
11–17	188	21.9	34	15.3
>17	185	21.6	35	15.8
Died	31	3.6	10	4.5
Discharged posthospital				
Home	744	86.7	174	78.4
Specialized hospital	17	2.0	8	3.6
Rehabilitation	66	7.7	21	9.5
Missing	31	3.6	19	8.6
Intensive care unit stay (days)*	2 (1, 4.5)		2 (1, 4)	
Hospital stay (days)*	4 (2, 8)		2.5 (1, 5)	

* Lengths of stay reported as medians with 25th and 75th quartiles.

TABLE 3. Types of Injury That Children Sustained in ATV Crashes in Pennsylvania (*n* = 858) and North Carolina (*n* = 222) Based on the First ICD-9-CM Codes

	Pennsylvania		North Carolina	
	<i>n</i>	%	<i>n</i>	%
Head	317	36.9	64	28.8
Face	78	9.1	28	12.6
Spinal cord	32	3.7	12	5.4
Thoracic	61	7.1	11	5.0
Abdominal	92	10.7	27	12.2
Extremity, vascular, and peripheral nerve	251	29.3	72	32.4
Burn	1	0.1	2	0.9
Unspecified	26	3.0	6	2.7

indicated by a GCS of ≤ 8 . Most children were discharged home (88.6%) from the hospital. The remaining living children were sent to specialized hospitals for additional care (2.3%) or to a rehabilitation or skilled nursing facility (8.1%).

Injuries and Deaths

Injury type for all children are shown (Table 3). Head and facial injuries made up the largest proportion of all injuries in this series (45.1%). Of the 381 children with any type of head injury, 53 (13.9%) sustained cerebral lacerations, and 108 (28.3%) sustained an intracranial hemorrhage. There were 70 deaths identified in the 2 states (Table 4). Forty-one deaths were identified by the trauma registry. The CPSC data from Pennsylvania identified an additional 12 children who were not in the Pennsylvania Trauma Registry. The North Carolina OCME identified 17 North Carolina deaths not included in the trauma registry. The primary cause of death from all sources for children in ATV crashes was head injuries (45.7%). Four of the children identified in the trauma database with a primary head injury also sustained other severe injuries, which may have contributed to their deaths (abdominal and thoracic injuries). Approximately 19% of children who died of a primary head injury were helmeted.

DISCUSSION

Children admitted to trauma hospitals secondary to ATV injury in Pennsylvania had different characteristics than children admitted to trauma hospitals in North Carolina. These differences included older

age, a higher percentage of helmet use, and fewer crashes in state parks in Pennsylvania. This pattern seems to be consistent with the intent of the Pennsylvania ATV regulations.

ATVs are used largely as recreational vehicles; therefore, safety should be a priority. Since their introduction in the early 1970s, it has been recognized that ATVs are a significant cause of both morbidity and mortality in children. Younger child age and male gender have been associated with a higher risk of injury.^{5,15} Our results are consistent with these findings. This study also confirms the ongoing morbidity from ATV use, with over 40% of the children requiring intensive care and ~8% of children requiring inpatient rehabilitation posthospitalization. Head and facial injuries comprised the largest number of injuries in this series; however, more than half of the injuries sustained were to other body areas.

Death was not infrequent, with ~1 in 16 crashes in this trauma-center population leading to a child's death. Although helmet use was associated with a better GCS, helmets were worn by 19% of children who died from head injury. Helmets may offer insufficient protection, because the ATVs are heavy and can attain relatively high speeds. More than half of the children died from causes other than head injury, including spinal cord, thoracic, and abdominal injuries and asphyxiation. These types of injuries are unlikely to be affected by helmet use.

This study has several limitations. Because the data are ecologic, potential individual-level confounders of the effect of regulations are lacking; thus, bias is possible.¹⁶ For example, not everyone in a given state will wear a helmet regardless of the regulations. Potential state-specific confounders such as societal attitudes toward regulation and access to designated state park areas were not assessed. Additionally, this is not a population-based study but a sample of children who were injured severely and in need of hospitalization at a trauma center or children who died before hospitalization. Thus, it may not be representative of the majority of children riding ATVs, and firm conclusions about the utility of the ATV regulations for all injuries in Pennsylvania cannot be drawn. The total number of child-hours riding ATVs in Pennsylvania and North Carolina is unknown; therefore, ATV-specific mortality rates cannot be calculated. Although helmet use decreased the risk of head and facial injury in this series, it likely

TABLE 4. Deaths Due to ATV Crashes With Percent of Helmet Use in North Carolina and Pennsylvania Including CPSC and Medical Examiner Data (January 1997 to July 2000)

Type of Injury	Helmet (<i>n</i> = 18)		No Helmet (<i>n</i> = 33)		Unknown Use (<i>n</i> = 19)		Total (<i>n</i> = 70)	
	<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)
Head	6	(33.3)	17	(51.5)	9	(47.4)	32	(45.7)
Spinal cord/neck	4	(22.2)	2	(6.1)	1	(5.3)	7	(10.0)
Thoracic	2	(11.1)	2	(6.1)	0		4	(5.7)
Abdominal	2	(11.1)	2	(6.1)	1	(5.3)	5	(7.1)
Extremity and vascular	0		3	(9.1)	2	(10.5)	5	(7.1)
Asphyxiation	1	(5.6)	1	(3.0)	0		2	(2.9)
Multiple internal	2	(11.1)	3	(9.1)	4	(21.1)	9	(12.9)
Unspecified	1	(5.6)	3	(9.1)	2	(10.5)	6	(8.6)

underrepresents the true utility of helmets, because the number of children who did not require trauma care due to helmet use is unknown. Despite these drawbacks, this study does show a pattern of injury seen in the trauma centers consistent with the intent of the ATV regulations in Pennsylvania.

ATV deaths have been increasing yearly from 1997 through 2002.¹⁷ The CPSC reports that 37% of all injuries and 33% of all fatalities due to ATVs since 1985 have occurred in children <16 years old. This makes consideration of ATV legislation an important public health issue. Legislation has been shown to be helpful in increasing bicycle helmet use by children.¹⁸ This study is consistent with an effect of ATV regulations in Pennsylvania. However, it also highlights the continued serious morbidity and mortality suffered by children injured on ATVs. States considering regulation of ATV use by children may wish to consider following the American Academy of Pediatric guidelines as the most effective way of preventing ATV-related injury and death.¹ These recommendations include no use of ATVs by children <16 years old, use of protective gear for the head and eyes, no nighttime driving, no concurrent use of alcohol, and no driving with a passenger.

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