

All-Terrain Vehicle and Bicycle Crashes in Children: Epidemiology and Comparison of Injury Severity

By Rebecca L. Brown, Matthew E. Koeplinger, Charles T. Mehlman, Michael Gittelman, and Victor F. Garcia
Cincinnati, Ohio

Background/Purpose: Despite statements by the American Academy of Pediatrics (AAP) and the US Consumer Product Safety Commission (CPSC) against the use of all-terrain vehicles (ATVs) by children under the age of 16 years, nearly half of ATV-related injuries and over 35% of all ATV-related deaths continue to occur in this age group. Because ATV and bicycle crashes have been associated with serious injury in children, the authors compared the demographics, mechanism of injury, injury severity, and outcome of children with ATV- and bicycle-related injuries. Further, the authors sought to identify whether ATV-related injuries elicited changes in risk-taking behavior.

Methods: A retrospective, comparative analysis of 109 children admitted for ATV-related injuries and 994 children admitted for bicycle-related injuries to a level 1 pediatric trauma center between January 1991 and June 2000 was performed. A phone survey was conducted to determine self-reported changes in safety behaviors or use patterns after ATV injury.

Results: Mean age was 11.1 ± 3.5 years (range, 2 to 18 years) for ATV crashes versus 9.4 ± 3.3 years (range, 1 to 17 years) for bicycle crashes ($P < .05$). Ninety-three percent of ATV crashes occurred in children less than 16 years of age; 31% in children ≤ 10 years of age; and 7% in children ≤ 5 years of age. Male-to-female ratio was about 3:1 for both groups. White race accounted for 97% of ATV injuries compared with 79% of bicycle injuries ($P < .05$). Falls from ATVs or bicycles were the most common mechanism of injury (41% v 59%, respectively). Collisions with motor vehicles were more common for bicyclists (32% v 10%), whereas collisions with stationary objects were more common among ATV riders (27% v 9%). Sixteen percent of ATV crashes were caused by a roll-over mechanism. Mean injury severity score (ISS) were significantly higher for victims of ATV crashes (8.3 ATV v 6.7 bicycle; $P < .05$). ATV-

related trauma was associated with multiple injuries, more operative interventions, and longer hospital stays. Location and distribution of injuries were similar for both groups. Helmet use was low in both groups but higher for ATV riders (23% v 8%; $P < .5$). Mortality rate was similar for both groups (0.9% for ATV riders v 0.7% for bicyclists). There was a 39% response for the phone survey post-ATV injury. Twenty-three of 43 (53%) respondents owned the ATV, and 70% of these received safety information at the time of purchase. However, only 14% of injured riders received any formal training before riding ATVs. Postinjury, 60% of children continued to ride, although 42% reported decreased riding time. Fifty-four percent of children reportedly wore helmets preinjury, and there were no changes in helmet usage postinjury. There were no differences in pre- and postinjury parental supervision (61% v 65%).

Conclusions: Both ATV and bicycle-related injuries occur predominantly in boys, but ATV victims are older and almost all are white. Almost all ATV injuries occurred in children under the age of 16 years. Although both ATV and bicycle crashes cause severe injuries in children, injury severity is higher for ATV crashes in terms of multiple injuries, need for operative intervention, and longer length of stay. Despite severe injuries, the majority of children injured by ATVs continue to ride, albeit fewer hours per day, and safety behaviors are unaltered. These data reinforce the current AAP stance that legislation prohibiting the use of ATVs in children under the age of 16 years without a valid driver's license should be pursued and enforced aggressively.

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INDEX WORDS: All-terrain vehicle, bicycle, injuries, injury severity.

SINCE THEIR INTRODUCTION in the 1970s as a "nearly unbreakable toy,"¹ all-terrain vehicles (ATVs) have enjoyed immense popularity among both adults and children. It is estimated that nearly 4 million ATVs currently are in use in the United States.² These powerful machines commonly are used for farming, hunting, and recreation by people of all ages. However, ATVs are sophisticated pieces of heavy machinery. They require a high degree of coordination, muscle strength, mature judgement, and experience for safe operation and, as a result, continue to be a source of severe injury for children who are generally lacking in these skills.

Previous studies have documented the epidemiology and injury patterns associated with ATV-related trauma,³⁻²⁰ but none have compared these findings with

From the Departments of Pediatric Surgery, Pediatric Orthopedic Surgery, and Emergency Medicine, Children's Hospital Medical Center, Cincinnati, OH.

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Matthew E. Koeplinger, a Musculoskeletal Outcomes Research Fellow, was funded by the Department of Pediatric Orthopedic Surgery.

Address reprint requests to Rebecca L. Brown, MD, Assistant Professor of Clinical Surgery and Pediatrics, Assistant Director of Trauma Services, Department of Pediatric Surgery, Children's Hospital Medical Center, OSB-3, 3333 Burnet Ave, Cincinnati, OH 45229-3039.

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those for the most popular recreational vehicle in children, the bicycle. There is a perception by the general public that bicycles and ATVs are equally nonthreatening activities for children, further reinforced by the fact that neither requires a license to operate. However, although one is motorized and the other is not, both leave the body fully unprotected and vulnerable to similar types of injury. Because serious injuries occur with both ATV and bicycle crashes, we sought to characterize and analyze injuries sustained by children in ATV crashes and compare them with a control group of children involved in bicycle crashes. Because ATVs are immensely more powerful, we hypothesized that children injured on ATVs would incur more serious injuries, require more operations, and have more prolonged hospital stays than children injured in bicycle-related trauma.

We also were curious as to whether children injured by ATVs were provided with adequate safety information and formal training before riding their ATVs and if being injured in an ATV-related incident elicited changes in vehicle usage or safety practices.

MATERIALS AND METHODS

We queried our Trauma Registry to identify all children admitted to Children's Hospital Medical Center, Cincinnati, OH, an accredited level 1 pediatric trauma center, with either ATV- or bicycle-related injuries over a 9½-year period (January 1991 through June 2000). Trauma registry data were corroborated by review of charts and radiologic studies. Data obtained included demographic variables (age, gender, race), mechanism of injury, injuries sustained, operative procedures, injury severity scores (ISS), emergency department Glasgow Coma Score (ED GCS), length of stay (LOS), helmet usage, and mortality rate. Injury severity score greater than 15, LOS greater than 7 days, and ER GCS less than 8 were considered markers for more severe injuries.

In addition, a follow-up phone survey was conducted for those children injured as a result of ATV crashes to determine whether children were provided with adequate safety materials or formal training before ATV use and to determine the presence of behavioral or use pattern changes after ATV injury.

Statistical analysis was performed using SAS version 8.01 for Windows. Data are reported as mean \pm SD (range). Continuous variables were analyzed using 2-tailed *t* tests, and categorical variables were analyzed using χ^2 or Fisher's Exact test. Probability values (*P* values) less than .05 were considered to be significant. All aspects of the study were approved by the Children's Hospital Medical Center Institutional Review Board.

RESULTS

Review of our Trauma Registry identified 109 children admitted for ATV-related injuries and 994 children admitted for bicycle-related injuries. Admissions for bicycle-related injuries remained steady at about 100 admissions per year over the study period (Fig 1A), whereas admissions for ATV-related injuries were relatively stable until 1999 when they more than doubled (Fig 1B). During the first 6 months of 2000, the number

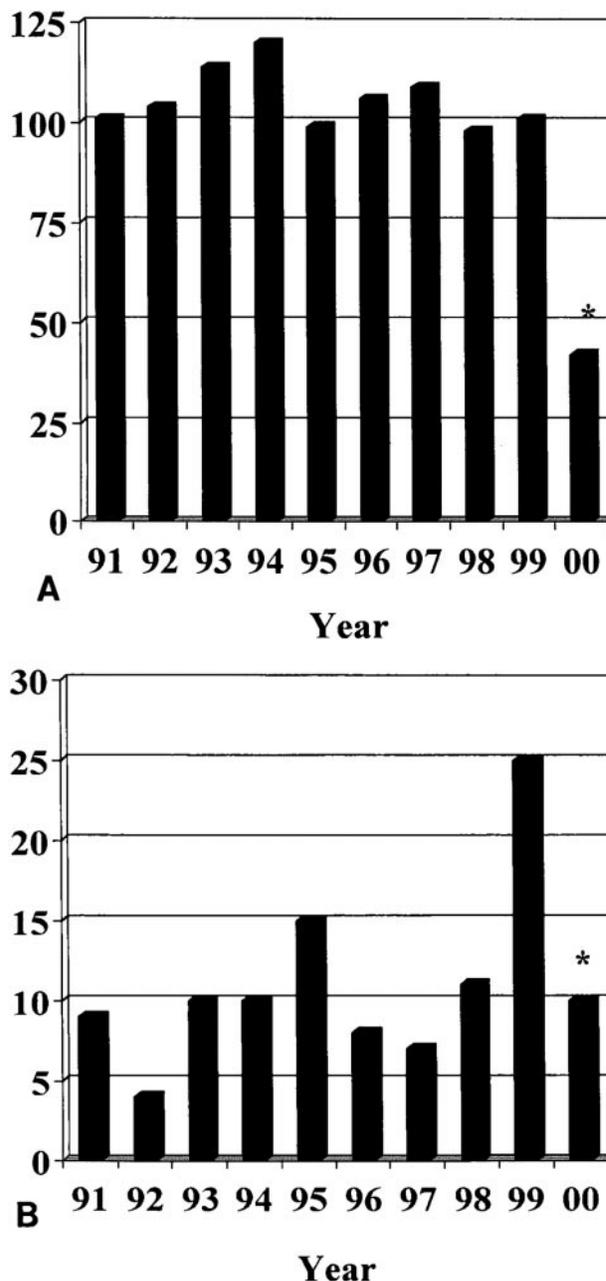


Fig 1. (A) Annual admissions for bicycle-related injuries. (B) Annual admissions for ATV-related injuries. Asterisk indicates admissions from January 1, 2000 to June 30, 2000.

of injuries remained higher than would have been predicted. As would be expected, injuries occurred most commonly in the warmer months (April through September) for both groups. Comparisons of demographics and injury severity are shown in Table 1. Children injured in ATV crashes were significantly older than children injured in bicycle crashes. The highest percentage of ATV-related injuries occurred among 11 to 15 year olds (62%), whereas the highest percentage of bicycle-related

Table 1. Comparisons of Demographic and Injury Severity Data for ATV Versus Bicycle Crashes

	ATV	Bicycle	P Value
Age	11.2 ± 3.5 (2-18)	9.4 ± 3.3 (1-17)	<.05
Male-to-female ratio	3.5:1	2.8:1	NS
Race (W:AA:O)	106:1:2	783:179:32	<.05
ISS	8.3 ± 7.22 (1-34)	6.7 ± 6.1 (1-75)	<.05
ISS > 15	13/109 (12%)	64/994 (6%)	<.05
Multiple injuries	73/109 (67%)	438/994 (44%)	<.05
Need for operative intervention	40/109 (37%)	271/994 (27%)	<.05
ER GCS*	14.2 ± 2.4 (3-15)	14.5 ± 2.0 (3-15)	NS
ER GCS < 8	6/99 (6%)	30/869 (3.5%)	NS
LOS (d)	6.3 ± 13.9 (1-126)	4.1 ± 6.4 (1-85)	NS
LOS > 7 d	15/109 (14%)	113/994 (11%)	NS
Helmet use*	21/90 (23%)	58/701 (8%)	<.05
Deaths	1/109 (0.9%)	7/994 (0.7%)	NS

*Some values unknown

Abbreviation: W, White; AA, African-American; O, Other; NS = Not Significant.

injuries occurred among 6 to 10 year olds (47%). The age distribution for both mechanisms of injury is depicted in Fig 2. The majority of patients (93%) involved in ATV crashes were less than 16 years of age; 31% were ≤10 years of age; and, disturbingly, 7% were ≤5 years of age. The male-to-female ratio for both groups was about 3:1. Almost all children with ATV-related injuries were white.

Falls from ATVs or bicycles were the most common mechanism of injury (41% v 59%, respectively). Bicyclists were about 3 times more likely to collide with moving objects, including motor vehicles and other bicyclists (32% v 10%), whereas ATV riders were about 3 times more likely to collide with stationary objects (27% v 9%). Sixteen percent of ATV injuries occurred as a result of a roll-over mechanism. Despite American Academy of Pediatrics (AAP) and Consumer Product Safety Commission (CPSC) warnings against carrying passen-

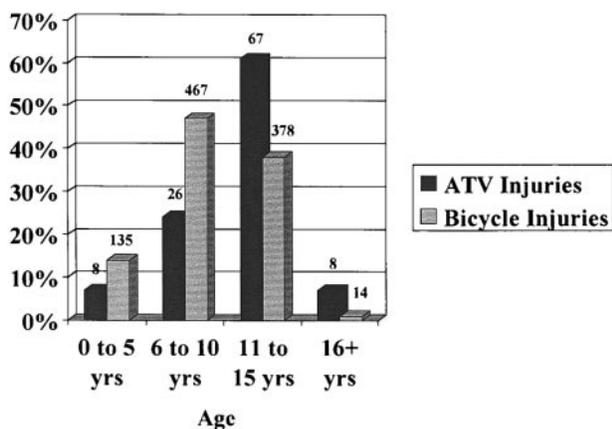


Fig 2. Age distribution for ATV versus bicycle injuries.

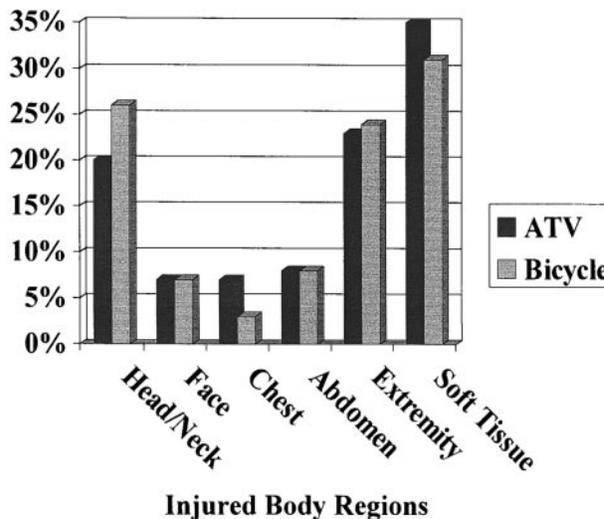


Fig 3. Injury distribution for ATV versus bicycle crashes.

gers on ATVs, 19 of the 109 children injured in ATV crashes were passengers.

Mean injury severity scores (ISS) were higher for children involved in ATV crashes than bicycle crashes. Importantly, ATV riders were twice as likely as bicyclists to have more serious injuries (ISS > 15). Those involved in ATV crashes were more apt to sustain multiple injuries and more often required surgical intervention. There was a tendency for children injured on ATVs to require longer hospitalizations; however, statistical significance was not achieved. The mortality rate was low in both groups.

Injury location and distribution of injuries were quite similar (Fig 3). Soft tissue injuries, including abrasions, contusions, lacerations, and burns, prevailed in both ATV and bicycle crash victims. Extremity fractures and head and neck injuries were the next most common injuries. Although head and neck injuries occurred in about 20% of ATV riders and 26% of bicyclists, there were no significant differences in the initial GCS between groups. As a measure of severe closed head injury, we compared those children with an initial GCS less than 8, and although no statistically significant differences were detected, almost twice as many children with ATV-related injuries met this criteria (6% ATV v 3.5% bicycle).

For ATV-related injuries, almost half of patients required orthopedic procedures for skeletal fractures, most commonly the tibia/fibula (40%). Twenty-nine percent had general surgical procedures; 9% craniotomies, 9% repair of mandibular fractures, and 5% other surgical procedures. For bicycle-related injuries, two-thirds of patients required orthopedic procedures for skeletal fractures, most commonly the humerus (36%). Thirteen percent underwent general surgical procedures; 9%

craniotomies, 6% repair of mandibular fractures, and 6% other surgical procedures.

Although helmet usage was poor among both groups, ATV riders were about 3 times more likely to wear a helmet than bicyclists. Also, although there were no differences in mean ISS or LOS for nonhelmeted versus helmeted bicyclists, mean ISS and LOS were higher for nonhelmeted versus helmeted ATV riders (9.9 v 5.9 and 7.4 v 3.7 days, respectively).

Parents of children and adolescents injured in ATV-related incidents were targeted for participation in our survey to determine risk-taking behaviors and whether ATV injury elicited changes in these behaviors. Of the 109 children, 47 parents were contacted, and 43 agreed to participate in the survey. Parents were asked whether safety materials (written or video) were distributed to them by the vendor at the time of purchase of the ATV and whether their child had received formal training before riding the ATV. They were questioned on the use of safety equipment (helmets, padded suits, boots, goggles) and asked to estimate the number of hours per week their children spent riding the ATV both pre- and postinjury. They were asked whether they still owned an ATV or if their child still had access to an ATV through friends or relatives. Parental supervision of young ATV riders also was noted.

The demographics for the group of respondents (n = 43) were as follows: mean age, 11.1 years (4 to 18 years); male-to-female ratio, 2.9:1; mean ISS, 7.3 (1 to 20); mean LOS, 4 days (1 to 25 days); 42% helmeted at time of injury; and 23% passengers. Twenty-three of 43 parents stated that they had purchased the ATVs on which their children were injured. Of these, 16 (70%) reported having received safety information at the time of purchase. The remaining 20 children were injured on ATVs belonging to friends or relatives. Only 6 of 43 children (14%) received any formal training before riding their ATV. Some parents refused free safety courses offered by the dealer because they considered them unnecessary.

Over 75% of those injured in an ATV-related incident still owned the same ATV or had purchased a new ATV after the injury. Of the 43 respondents, 29 reported that their children still had access to an ATV, either through family ownership or a friend or relative. Of this group, 26 continued to ride postinjury. For 6 children who were injured while riding for the first time, none continued to ride. There was a *decrease* in the parentally estimated riding time for 11 children after injury; *no change* in estimated riding time for 12 children; and an *increase* in estimated riding time for 3 children.

According to parental responses for the 26 children who continued to ride, 54% of children reportedly wore helmets both before and after the injury, whereas 42% *never* wore helmets either before or after. One child

began wearing a helmet after the injury. Additional safety equipment (ie, goggles, boots, or padded suits) was used both before and after injury in 58% of children, no equipment was used either before or after injury in 31% of children, and 8% of children started wearing additional safety equipment after the injury. Interestingly, one child wore safety equipment before, but not after, the injury. Preinjury, 26 of 43 children (61%) rode ATVs only with adult supervision. Of those who continue to ride, 65% were supervised by an adult.

To assess other risk-taking behaviors, we asked parents if their children rode bicycles and, if so, if they wore helmets. Thirty of 43 children (70%) reported bicycle use; however, less than half (43%) wore helmets when riding their bicycles. Parents were also asked whether their children had suffered any other traumatic injuries requiring the attention of a physician or an emergency room visit in the past 2 years, and about one-third replied affirmatively. In fact, 6 of 43 children required *multiple* visits to the emergency room for other injuries, and one child was injured in a second ATV crash.

DISCUSSION

It was recognized in the early 1980s that ATVs were dangerous and were responsible for a disproportionate number of injuries and deaths among users, especially children and adolescents.^{21,22} In May 1987, the Consumer Product Safety Commission (CPSC) issued a safety alert encouraging users to take a training course before riding ATVs, always wear a helmet, never ride double, and not to ride on paved roads or while under the influence of alcohol. They also recommended that children less than 16 years of age not be allowed to ride adult-sized ATVs and that children less than 12 years of age not be allowed to ride *any* ATV.²³ This led to a 10-year consent decree²⁴ in 1988 between the CPSC and ATV dealers banning all sales of 3-wheel ATVs, prohibiting the sale of adult-sized ATVs for use in children less than 16 years of age, and requiring dealers to provide training programs and issue extensive safety warnings for all potential buyers. This legally binding consent decree expired in 1998. In April 1998, the CPSC released the results of the 1997 ATV Exposure, Injury, Death, and Risk Studies² that showed a general decline in ATV-related injuries and deaths over the period of the decree.

It should be of concern to pediatric health care providers that although the *overall* number of injuries and deaths have diminished, they have remained constant in children less than 16 years of age, who account for almost half (47%) of all reported injuries and over 35% of all deaths.² Furthermore, children less than 12 years of age account for 15% of all deaths related to ATVs.² Not surprisingly, the CPSC estimates that ATV operators less than 16 years of age are 2.5 times more likely than

operators aged 16 to 34 years and 4.5 times more likely than operators aged 35 to 54 years to be seriously injured as a result of an ATV crash.² Because of these disturbing statistics, the American Academy of Pediatrics (AAP) issued an updated policy statement in June 2000 recommending passage of legislation that no one under the age of 16 without a valid driver's license should be permitted to use an ATV either on or off road.²⁵

Despite the national trends showing an overall decline in ATV injuries and deaths, we have seen an increase in ATV-related admissions at our level 1 pediatric trauma center over the past few years. Other centers have reported similar findings.^{4,6,7,26} Although our data obviously are skewed toward the pediatric population, it still is concerning that 93% of children admitted with ATV injuries are less than 16 years of age, despite warnings by the CPSC, AAP, and ATV dealers themselves against the use of ATVs in this age group. Disturbingly, nearly 10% of children are less than 6 years of age. It is equally alarming that despite prohibitions against carrying passengers on ATVs, almost 20% of children admitted with ATV-related injuries were passengers.

The bicycle is the most popular recreational vehicle and mode of transportation for children. The epidemiology and injury patterns for bicycle-related injuries have been studied extensively.²⁷⁻³⁴ With the rising popularity of ATVs among children and adolescents and their general perception as "toys," we sought to compare them with bicycles, a well-known entity in terms of epidemiology and injury severity. Our findings suggest that ATV-related injuries occur most commonly in children aged 11 to 15 years, whereas bicycle-related injuries occur most commonly in younger children aged 6 to 10 years. For both groups, boys outnumber girls about 3:1, which is consistent with the popular perception of boys as risk-takers. Almost all (97%) ATV victims are white.

Our findings clearly show that ATVs are significantly more dangerous than bicycles for children. Children riding ATVs sustain more serious injuries and are twice as likely to sustain severe injuries (ISS > 15). Almost 70% have multiple injuries, and nearly 40% require operative intervention. ATV victims also have slightly longer hospital stays, which is clinically but not statistically significant. Injury patterns and types of operative intervention are similar, although ATV riders are more likely to fracture lower extremities, whereas bicyclists more often fracture upper extremities.

Our findings also show that helmets are used more often by ATV riders than bicyclists, and, as such, head and neck injuries are slightly less common among those involved in ATV crashes. Moreover, injury severity and length of hospital stay are lower for helmeted versus unhelmeted ATV riders. Although helmet use was found to be higher for ATV riders than bicyclists, it still was

unacceptably low at only 23%. Rodgers³⁵ reports that helmet use by ATV riders would reduce the risk of nonfatal head injury by 64% and the risk of death by 42%. Legislation requiring mandatory helmet use in all ATV riders potentially could result in a significant reduction in the number of closed head injuries among this high-risk population.

The follow-up survey findings are limited to a subset of children with ATV-related injuries, and, admittedly, the response rate (39%) is relatively low. The possibility of recall bias also is acknowledged, because parents were asked to remember events occurring up to 9½ years before. Despite these limitations, some general observations can be made. It is clear from both our study and the 1997 CPSC survey² that, although most respondents reported receiving some form of safety information at the time of ATV purchase, only a small proportion of those injured in ATV crashes received any formal training before riding. This may be because of the fact that many children were riding used vehicles or those owned by friends or relatives and were not offered the formal training courses required by dealers. It is interesting that several parents actually refused training courses offered free by dealers because their children were already experienced enough. Perhaps this reflects a perception among parents that riding an ATV is similar to riding a bicycle, and formal training is unnecessary.

Being involved in an ATV crash does not appear to significantly influence vehicle usage patterns. Sixty percent of all injured children continued to ride postinjury. Forty-two percent of these, however, did report decreased riding times. It is worth noting that of the 2 respondents with severe injuries (ISS > 15), neither continued to ride, and for 6 first-time riders, none continued to ride. Many parents did report that although their children continued to ride after injury, that they showed increased apprehension toward the vehicle. Similar to ATV use patterns, safety practices (ie, use of helmets, padded suits, boots, or goggles; parental supervision) were unaltered after ATV injury.

Although touted as a recreational "toys," ATVs are powerful machines weighing 300 to 600 pounds and capable of achieving speeds up to 70 miles per hour. Children and adolescents lack the physical strength to adequately control these vehicles and do not possess the maturity, judgement, and experience to operate them safely. It is unfathomable that it is illegal for children to drive automobiles until they are 16 years of age, pass a driver's training class, and obtain a valid driver's license; yet, we permit even younger children to ride ATVs without helmets, safety gear, formal training, parental supervision, or licenses. ATVs are more dangerous than automobiles because the rider's body is fully exposed and not protected by the car's frame and body.

The consent decree aimed at reducing ATV-related injuries and deaths has been largely ineffective in the pediatric population. In fact, it may have worsened the situation by fostering an environment in which dealers are reluctant to provide safety equipment or formal instruction to children who are the intended operators for fear of litigation.⁴ Parents themselves have ignored all the warnings by the CPSC, AAP, and ATV dealers, and continue to purchase ATVs for their children's use. Even after severe ATV-related injuries, many parents continue to permit their children to ride.

Pediatric health care providers must unite in support of the recent AAP recommendations advocating legislation

prohibiting the use of ATVs both on and off road in children less than 16 years of age without a valid driver's license. Mandatory helmet laws for ATV riders and requirements for formal training courses before licensure must be enacted. By being proactive with anticipatory guidance for parents and legislation, pediatric health care providers can influence positively the number of ATV-related injuries and deaths in children.

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