

# A School-Based Study of Adolescent All-Terrain Vehicle Exposure, Safety Behaviors, and Crash Experience

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## ABSTRACT

**PURPOSE** More youth are killed every year in the United States in all-terrain vehicle (ATV) crashes than on bicycles, and since 2001, one-fifth of all ATV fatalities have involved victims aged 15 years or younger. Effectively preventing pediatric ATV-related deaths and injuries requires knowledge about youth riding practices. Our objective was to examine ATV use, crash prevalence, and riding behaviors among adolescent students in a rural state.

**METHODS** We administered a cross-sectional survey to 4,684 youths aged 11 to 16 years at 30 schools across Iowa from November 2010 to April 2013. Descriptive and comparative analyses were performed.

**RESULTS** Regardless of rurality, at least 75% of students reported having been on an ATV, with 38% of those riding daily or weekly. Among ATV riders, 57% had been in a crash. Most riders engaged in risky behaviors, including riding with passengers (92%), on public roads (81%), or without a helmet (64%). Almost 60% reported engaging in all 3 behaviors; only 2% engaged in none. Multivariable modeling revealed male youth, students riding daily/weekly, and those reporting both riding on public roads and with passengers were 1.61 (95% CI, 1.36-1.91), 3.73 (95% CI, 3.10-4.50), and 3.24 (95% CI, 2.09-5.04) times more likely to report a crash, respectively.

**CONCLUSIONS** Three-fourths of youths surveyed were exposed to ATVs. The majority of riders had engaged in unsafe behaviors and experienced a crash. Given this widespread use and the potentially considerable morbidity of pediatric ATV crashes, prevention efforts, including anticipatory guidance by primary care clinicians serving families at risk, should be a higher priority.

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## INTRODUCTION

Since 2001, youth aged 15 years and younger have represented nearly 30% of all US all-terrain vehicle (ATV)-related injuries and one-fifth of ATV-related deaths.<sup>1</sup> In fact, more children are killed in the United States each year from ATVs than from bicycle crashes.<sup>2</sup> Previous studies indicate that youth ATV operators have a 12 times greater risk of injury as compared with adults.<sup>3</sup> This increased risk is likely due to a number of factors including physical and mental immaturity, lack of training and experience, riding adult-size machines, and a greater likelihood of being a passenger.<sup>4-10</sup>

Despite the magnitude of the problem, there have been few published studies regarding ATV use, and these studies have mostly been limited to select rural and agricultural groups,<sup>7,11-14</sup> or ATV-owning households.<sup>15</sup> To our knowledge, this is the first study to provide epidemiology of ATV use and safety-related behaviors among a large cross-sectional sample of adolescents.

## METHODS

### Study Design

We recruited school districts to participate in an ATV safety education program through written or verbal communication with school nurses and

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administrators. Because previous studies showed that youth aged 12 to 15 years were at highest risk,<sup>8</sup> we targeted classes with students in this age range. Schools participated from across the state, although most were from eastern Iowa. This report includes all 30 participating schools from November 2010 through April 2013.

Before the safety program, an anonymous survey was electronically administered using TurningPoint technology (<http://www.turningtechnologies.com/polling-solutions/turningpoint>). TurningPoint displays survey questions on PowerPoint slides with answers selected using a hand-held clicker (Table 1). All students in the scheduled classes completed the questionnaire, each as a unique respondent. The University of Iowa Institutional Review Board approved this study.

### Classification of Schools by Rurality

School district rurality was determined using the zip code–based Rural Urban Commuting Area (RUCA) codes (<http://depts.washington.edu/uwrUCA/ruca-approx.php>). This classification takes into account the largest population center in the zip code area, as well as the proportion traveling to that center for work. Schools were coded into 4 RUCA categories: isolated rural, small rural, large rural, and urban. Because the large rural category had only 1 district, we combined large and small rural schools and designated this combined group as rural for analysis.

### Missing and Inconsistent Data

A total of 364 students failed to answer the question “How often do you ride an ATV?” and were excluded from analysis, as we could not determine their ATV exposure. Those responding “never” to the question about riding frequency were categorized as unexposed; all other answers placed the respondent in the exposed category. A total of 114 students categorized as exposed answered a subsequent safety behavior question with “Never been on an ATV”; this inconsistent response was treated as missing data.

### Data Analysis

We performed all analyses using SAS software, version 9.3 (SAS Institute Inc). All comparisons of categorical variables were completed using the Pearson  $\chi^2$  test. All *P* values are for a 2-sided test. We used hierarchical multivariable logistic regression analysis to calculate adjusted odds ratios and 95% CIs for dichotomous variables, after controlling for covariables and clustering within schools to control for a high correlation of ATV-related exposures within each school. Covariables for inclusion in the model were selected a priori based on previous research. Students with missing data for 1 or more model variables were not included in multivariable analysis.

## RESULTS

### Exposure to ATVs

Of the 4,684 students surveyed, 92% (4,320) responded to the question about ATV exposure. Table 2 shows their demographics. The proportion of female students and students aged 14 years or older was higher in the rural category, which included a large rural high school.

Seventy-seven percent of students reported having ridden on an ATV (Table 3). By school, this value ranged from 61% to 95%. Exposure was higher for students from isolated rural schools as compared with other schools (*P* < .001), but there was no difference between rural and urban schools. Among those exposed, 38% reported they rode frequently, defined as daily or weekly. Although there was no difference in overall ATV exposure by sex, a higher proportion of male students reported riding almost daily (*P* < .001).

### Riding Behaviors

More than 90% of exposed students reported having been on a vehicle with multiple riders (Table 3), with a higher proportion seen for female students relative to male peers (*P* < .001). More than 80% of exposed students reported riding on public roads, with no differences found by sex or rurality. The rate of regular helmet use (signified by a response of always or almost always) among students was only 17%, and 64%

**Table 1. Survey Questions and Response Options Probing ATV Exposure and Riding Behavior**

Question	Response Options
Q1. How old are you (years)?	–
Q2. What is your gender?	Male Female
Q3. How often do you drive or ride on an ATV?	Almost daily About once a week About once a month Only a few times a year Never
Q4. Have you ever been in an ATV crash (rolled over, hit something, fallen off)?	Yes No Never been on an ATV
Q5. Have you ever ridden or driven an ATV with more than 1 person on the ATV?	Yes No Never been on an ATV
Q6. Have you ever ridden or driven an ATV on a public road?	Yes No Never been on an ATV
Q7. How often do you wear a helmet when riding an ATV?	Always or almost always More than half the time Less than half of the time Never or almost never Never been on an ATV

ATV = all-terrain vehicle.

reported never or almost never wearing a helmet. Helmet use was lower among female students ( $P < .001$ ) and isolated rural students ( $P < .001$ ) as compared with their respective peers. Only 2% of riders reported having engaged in none of the 3 unsafe behaviors, while 58% reported engaging in all 3 (Table 4).

**Experienced a Crash**

Fifty-seven percent of students reported having been in at least 1 ATV crash (Table 4). Larger proportions of male students ( $P < .001$ ) and students from isolated rural schools ( $P = .01$ ) reported having been in a crash, and the proportion increased with age ( $P = .02$ ).

**Multivariable Analysis**

**Odds of ATV Exposure and Safety Behaviors**

The likelihood of ATV exposure was 39% higher for youths aged 16 years relative to youths aged 11 years and for students from isolated rural schools relative to peers from urban schools (Table 5). Male students were about 40% less likely than female peers to have ridden with or as passengers. Monthly and daily/weekly riders were 3.5 and 5.6 times more likely, respectively, to have ridden on public roads than those riding only a few times a year. Students from isolated rural schools were 26% less likely, and from rural schools 39% less likely, to regularly wear helmets, as compared with

urban students. Monthly riders were 20% more likely to report helmet use than those riding only a few times a year, but there was no difference between the most and least frequent riders.

**Odds of Having Crashed**

Male students were 61% more likely to report having been in a crash (Table 6). Riding monthly or daily/weekly increased the likelihood by 2-fold and 3.7-fold, respectively, relative to riding a few times a year. Students who reported never riding with pas-

**Table 2. Demographic Characteristics of Study Population**

Characteristic	All, No. (%)	Isolated Rural, No. (%)	Rural, No. (%)	Urban, No. (%)	P Value <sup>a</sup>
Total number	4,684 (100)	1,554 (33)	1,834 (39)	1,296 (28)	-
Sex					
Male	2,153 (49)	760 (52)	775 (45)	618 (50)	.001
Female	2,255 (51)	710 (48)	929 (55)	616 (50)	
Age, y					
11	690 (16)	263 (19)	228 (13)	199 (16)	<.001
12-13	2,526 (58)	780 (58)	882 (52)	864 (68)	
14-15	952 (22)	285 (21)	463 (27)	204 (16)	
16	54 (4)	26 (2)	123 (7)	5 (<1)	

Note: Column totals may not equal overall population totals because of missing or indeterminate responses.

<sup>a</sup>  $\chi^2$  analysis for comparison of proportions.

**Table 3. ATV Exposure and Riding Behaviors (N = 4,320)**

Exposure/Behavior	All, No. (%)	Male, No. (%)	Female, No. (%)	P Value <sup>a</sup>	Isolated Rural, No. (%)	Rural, No. (%)	Urban, No. (%)	P Value <sup>a</sup>
Exposed to ATVs								
Yes	3,344 (77)	1,620 (79)	1,626 (76)	.095	1,196 (82)	1,267 (75)	881 (76)	<.001
No	976 (23)	442 (21)	502 (24)		269 (18)	429 (25)	278 (24)	
How often do you drive or ride on an ATV?								
Almost daily	666 (20)	378 (23)	263 (16)	<.001	274 (23)	221 (17)	171 (20)	.005
About once a week	606 (18)	301 (19)	289 (18)		226 (19)	231 (18)	149 (18)	
About once a month	636 (19)	276 (17)	341 (21)		221 (18)	231 (18)	184 (22)	
Only a few times a year	1,436 (43)	665 (41)	733 (45)		475 (40)	584 (46)	337 (40)	
Have you ever ridden or driven an ATV with more than 1 person on the ATV?								
Yes	2,948 (92)	1,409 (90)	1,455 (94)	<.001	1,086 (92)	1,065 (91)	797 (93)	.19
No	261 (8)	155 (10)	100 (6)		89 (8)	109 (9)	63 (7)	
Have you ever ridden or driven an ATV on a public road?								
Yes	2,534 (81)	1,237 (81)	1,226 (80)	.75	889 (82)	952 (79)	693 (81)	.096
No	604 (19)	292 (19)	298 (20)		191 (18)	255 (21)	158 (19)	
How often do you wear a helmet when riding an ATV?								
Always, almost always	530 (17)	288 (19)	233 (15)	<.001	185 (14)	163 (22)	182 (22)	<.001
More than half the time	251 (8)	139 (9)	104 (7)		99 (6)	75 (9)	77 (9)	
Less than half the time	366 (12)	200 (13)	157 (10)		142 (10)	119 (13)	105 (13)	
Never, almost never	2,032 (64)	921 (59)	1,052 (68)		731 (70)	833 (56)	468 (56)	

ATV = all-terrain vehicle.

Data are provided as No. (column percentages). Column totals may not equal overall population totals because of missing or indeterminate responses.

<sup>a</sup>  $\chi^2$  analysis for comparison of proportions.

**Table 4. Unsafe Behaviors and Crashes Among ATV-Exposed Students (N = 4,320)**

Characteristic	Number of Unsafe Behaviors <sup>a</sup>				P Value <sup>b,c</sup>	Ever Been in a Crash		
	0, No. (%)	1, No. (%)	2, No. (%)	3, No. (%)		Yes, No. (%)	No, No. (%)	P Value <sup>b</sup>
All exposed	66 (2)	299 (9)	1,045 (31)	1,914 (58)	–	1,816 (57)	1,386 (43)	–
Sex								
Male	37 (2)	158 (10)	512 (32)	908 (56)	.14	961 (62)	599 (38)	<.001
Female	25 (2)	133 (8)	507 (31)	949 (59)		796 (51)	760 (49)	
Rurality								
Isolated rural	19 (2)	99 (8)	374 (31)	700 (59)	.37	694 (60)	467 (40)	.01
Rural	32 (3)	112 (9)	407 (32)	706 (56)		642 (54)	556 (46)	
Urban	15 (2)	88 (10)	264 (30)	508 (58)		480 (57)	363 (43)	
Age, y								
11	14 (3)	65 (13)	165 (32)	266 (52)	<.001	251 (51)	238 (49)	.02
12-13	29 (2)	165 (9)	584 (32)	1,033 (57)		998 (57)	762 (43)	
14-15	14 (2)	52 (8)	209 (31)	404 (59)		367 (56)	291 (44)	
16	4 (4)	3 (3)	27 (24)	79 (70)		66 (67)	32 (33)	

Note: Data provided as No. (row percentage). Row totals may not equal overall population totals because of missing data.

<sup>a</sup> Unsafe behaviors were ridden/driven with more than 1 person, ridden/driven on public roads, and almost never/never wear a helmet.

<sup>b</sup>  $\chi^2$  analysis for comparison of proportions for indicated variable.

<sup>c</sup> Fisher exact test used for comparison by age where data included cell sizes smaller than 5.

sengers but having been on the road (No, Yes) were 77% more likely, and those reporting both behaviors (Yes, Yes) were more than 3 times more likely, to report having been in a crash than peers reporting neither behavior.

## DISCUSSION

### Youth Exposure to ATVs

Regardless of school rurality, at least three-fourths of students had previously ridden an ATV, with almost 40% of those riding daily or weekly. Previous exposure studies reported similarly high percentages, including 97% of youth attending a national Future Farmers of America convention and 99% of Connecticut children at agricultural fairs.<sup>7,11</sup> Additionally, 44% of Illinois 4-H club members surveyed had ridden an ATV in the previous 6 months,<sup>12</sup> and 59% of Arkansas youth at agricultural educational programs had ridden in the previous month.<sup>13</sup> Taken together, these studies demonstrate that high adolescent ATV ridership is not limited to a single state or to more select youth populations.

**Table 5. Multivariable Analysis of ATV Exposure and Unsafe Behaviors (N = 4,320)**

Characteristic	Exposure/Behavior			
	Rode on an ATV, aOR <sup>a</sup> (95% CI)	Rode/Drove With >1 Person, aOR <sup>a</sup> (95% CI)	Rode on a Public Road, aOR <sup>a</sup> (95% CI)	Wear a Helmet, aOR <sup>a</sup> (95% CI)
Sex				
Male	1.11 (0.94-1.32)	0.61 (0.45-0.82)	0.96 (0.83-1.12)	1.40 (1.18-1.67)
Female	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Age, y				
11	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
12-13	1.00 (0.76-1.33)	0.61 (0.38-0.96)	0.54 (0.39-0.75)	1.36 (1.02-1.81)
14-15	1.03 (0.80-1.32)	0.77 (0.55-1.08)	0.70 (0.59-0.83)	1.24 (1.01-1.52)
16	1.39 (1.02-1.89)	2.74 (1.11-6.74)	1.11 (0.73-1.69)	0.76 (0.51-1.12)
Rurality				
Isolated rural	1.39 (1.11-1.75)	0.95 (0.58-1.57)	0.93 (0.64-1.35)	0.74 (0.55-0.98)
Rural	0.90 (0.70-1.17)	0.79 (0.47-1.34)	0.78 (0.57-1.08)	0.61 (0.41-0.90)
Urban	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Riding frequency				
Daily/weekly	NA	2.03 (1.51-2.74)	5.64 (3.91-8.13)	0.94 (0.80-1.10)
Monthly		2.24 (1.58-3.18)	3.48 (2.68-4.52)	1.20 (1.01-1.43)
Yearly		1.00 (ref)	1.00 (ref)	1.00 (ref)

NA = not applicable; aOR = adjusted odds ratio; ref = reference category.

Note: Students with missing data for 1 or more of the variables in the model were not included in multivariable analysis.

<sup>a</sup> Controlled for all variables in the table.

### Riding With Passengers

More than 90% of exposed students in our study reported having ridden with more than 1 person on the ATV. This finding demonstrates again that carrying passengers on ATVs is a highly common behavior, even more prevalent in our study than the 50% to

**Table 6. Multivariable Analysis of Having Experienced a Crash (N = 4,320)**

Characteristic	Experienced a Crash, <sup>a</sup> aOR <sup>b</sup> (95% CI)
Sex	
Male	1.61 (1.36-1.91)
Female	1.00 (ref)
Age, y	
11	1.00 (ref)
12-13	0.89 (0.68-1.15)
14-15	1.12 (0.88-1.42)
16	1.13 (0.80-1.60)
Riding frequency	
Daily/weekly	3.73 (3.10-4.50)
Monthly	2.07 (1.75-2.45)
Yearly	1.00 (ref)
Rurality	
Isolated rural	1.26 (0.78-2.05)
Rural	1.04 (0.69-1.58)
Urban	1.00 (ref)
Riding with >1 person/on road	
No/no	1.00 (ref)
Yes/no	1.30 (0.84-2.20)
No/yes	1.77 (1.14-2.74)
Yes/yes	3.24 (2.09-5.04)

aOR = adjusted odds ratio; ref = reference category.

<sup>a</sup> Students with missing data for 1 or more of the variables in the model were not included in multivariable analysis.

<sup>b</sup> Controlled for all variables in the table. Helmet use was not included in the model because it was not associated with crash risk and did not affect the aORs for other variables.

88% rates previously reported.<sup>7,11-13,16</sup> In addition, more female students reported having ridden with multiple riders, which is consistent with previous reports that female youth were more likely to be injured passengers than male peers.<sup>8</sup>

From 1985 to 2009, 29% of all ATV-related fatality victims in the United States were operators with passengers or were passengers themselves.<sup>17</sup> Extra riders increase the likelihood of crashing by interfering with "active riding," that is, the body shifting required for maintaining the vehicle-rider center of gravity to prevent a rollover. Passengers can also interfere with steering or distract the driver, and are at higher risk of being ejected, often to the rear, which is more likely to result in a severe head injury.<sup>18</sup>

A previous study found that more than 95% of youth injured were on adult-size ATVs.<sup>5</sup> Although almost all ATVs are specified as single-rider vehicles, seat lengths for adult-size vehicles vary considerably, with many long enough to accommodate multiple riders.<sup>19,20</sup> This configuration likely encourages carrying passengers, especially among youth.<sup>4</sup> Also, adult-size vehicles with longer seats often have seat fronts closer to the steering mechanism.<sup>20</sup> This positioning may allow

children to reach the handle grips and operate vehicles that are too large and fast for them to ride safely.

### Riding on the Road

More than 80% of youth reported having ridden ATVs on public roads, despite Iowa laws prohibiting such use, unless licensed and driving for work-related purposes. Previous studies found similarly high percentages of road use in response to general roadway questions and somewhat lower ones for riding on paved highways.<sup>11,16</sup> Since 1998, fatal roadway crashes have increased at more than twice the rate of those off road,<sup>17</sup> and despite most riding being off road,<sup>6</sup> more than 60% of fatal ATV crashes occur on roadways.<sup>17,21</sup> Although collisions are a factor, two-thirds of roadway deaths do not involve other vehicles.<sup>17</sup> Higher speed, coupled with the fact that ATVs are not designed for roadway use, may be major contributors to these fatalities.

### Helmet Use

Less than one-fifth of students in our survey routinely wore a helmet, and the majority never or almost never did. This finding is consistent with studies of pediatric trauma patients showing rate of helmet use ranging from 16% to 28%.<sup>8,17,21,22</sup> Female riders were less likely than male peers to wear helmets, possibly reflecting a previous observation that passengers have lower rates of helmet use than operators and that females are more likely to be passengers.<sup>8</sup>

Brain injuries are among the leading cause of death and disability from ATV crashes.<sup>23-25</sup> They are more likely to occur on the roadway than off road, even when controlling for helmet use.<sup>8,17</sup> This pattern may be due to forces in roadway crashes great enough to exceed the protective capacity of helmets. Brain injuries are also more likely among children younger than 16 years as compared with adults.<sup>8,17</sup> Helmets are estimated to reduce the risk of fatal ATV-related head injuries by 40% and of nonfatal head injuries by 60% or more.<sup>8,17,25-27</sup>

### ATV Crashes

Almost 60% of exposed students in our study reported having been in at least 1 crash in their lifetime. This value is similar to the 44% of children at Connecticut agricultural fairs and the 67% of Illinois 4-H club members reporting having crashed.<sup>7,12</sup> The likelihood and severity of ATV crashes have been shown to increase when multiple risk factors are involved.<sup>9</sup> More than one-half of our exposed students reported engaging in all 3 unsafe behaviors.

### Anticipatory Guidance

Primary care clinicians should be aware of possible ATV exposure, even among relatively young patients

and nonfarm families. Children from urban localities could be exposed, particularly those from suburban acreages or who visit rural areas. Nonrural youth may be at even greater risk of crash and injury if they lack ATV riding experience.<sup>3</sup>

An American Academy of Pediatrics policy statement recommends that no child younger than 16 years of age ride an ATV.<sup>28</sup> Although we support this recommendation, it is unlikely to be an effective message for many families. Primary care clinicians are in a unique position as a trusted source to offer ATV safety advice to patients and their families.

Medical organizations, including the American Academy of Family Physicians, promote injury prevention counseling in their health maintenance guidelines.<sup>29</sup> Among anticipatory guidance interventions, safety counseling is supported by the best evidence.<sup>30-34</sup> Although surveyed caregivers agreed that ATV injury prevention guidance is important to provide, only a minority performed this counseling.<sup>35,36</sup>

Time constraints are always a concern as anticipatory guidance recommendations for health care visits are quite extensive. However, clinicians should determine whether their patients are exposed to ATVs and if so, should strongly consider injury prevention counseling. ATV use meets key criteria for guidance importance: high severity and frequency of injury, availability of environmental strategies to prevent injury, and evidence that the strategies are effective.<sup>37</sup> Routine counseling by clinicians could greatly increase the number of adolescents receiving ATV safety education.

### Limitations

Students may have experienced occasional difficulties with TurningPoint technology, either failing to answer a question or entering incorrect data. A total of 455 categorized as unexposed provided answers to subsequent behavior questions that suggested they did indeed ride ATVs. If all these students were included, the overall exposure rate would increase to 88%. Thus, categorizing these students as unexposed may have underestimated exposure. A total of 114 students categorized as exposed also gave inconsistent answers, endorsing "Never been on an ATV" in response to 1 or more behavior questions. If all of these students were unexposed, then overall exposure would be reduced by 2% to 75%. Although missing or inconsistent answers treated as missing could have affected final results, the large number surveyed likely reduced this possibility.

As with any self-report data, social desirability bias and peer-related effects could have affected results. Several factors decreased this likelihood: answers were obtained anonymously, timing prevented peer interac-

tions during or between questions, and students may not have recognized behaviors as unsafe.

Student groups not evaluated included those home schooled and those with severe disabilities. In addition, Iowa Department of Education data and RUCA coding indicate that Iowa middle school students are 50% urban, 31% rural, and 19% isolated rural. This distribution compares with 27%, 39%, and 34%, respectively, for our sample. Our study's more rural population may limit its overall generalizability to the state. However, surveyed urban students reported exposure levels similar to their rural peers. Therefore, ATV exposure beyond our state's more rural communities should not be discounted.

Our findings may not be generalizable to all states, even those with student populations similar to Iowa's. However, high exposure rates were seen in previous studies of geographically diverse pediatric populations.<sup>7,11-13,16</sup> Furthermore, Iowa's pediatric ATV mortality rate is comparable to or lower than that of 21 other states,<sup>38</sup> suggesting Iowa is not unique regarding ATV use. Finally, all states, even those with large metropolitan areas, have rural and suburban populations. In fact, the states with the top 10 pediatric ATV fatality rates include California, Texas, Pennsylvania, Florida, and New York.<sup>1</sup>

### Conclusions

A high proportion of students in our study reported being exposed to ATVs. Most practiced unsafe riding behaviors and had experienced at least 1 crash. These data illustrate the critical need for promoting safer behaviors among youth. Robust ATV injury prevention efforts are more widely needed, including training and well-enforced legislation. Primary care clinicians could play an important role in decreasing pediatric ATV-related injuries and deaths through routine anticipatory guidance.

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