Journal of Safety Research 60 (2017) 71–78

Contents lists available at ScienceDirect

Journal of Safety Research

journal homepage: www.elsevier.com/locate/jsr

All-terrain vehicle safety knowledge, riding behaviors and crash experience of Farm Progress Show attendees

Charles A. Jennissen, [a,*] Karisa K. Harland, [a] Kristel Wetjen, [b,c] Pamela Hoogerwerf, [c] Lauren O'Donnell, [c] Gerene M. Denning [a]

[a] Department of Emergency Medicine, Roy J. and Lucille A. Carver College of Medicine, University of Iowa, Iowa City, Iowa, United States
[b] Department of Surgery, Roy J. and Lucille A. Carver College of Medicine, University of Iowa, Iowa City, Iowa
[c] University of Iowa Stead Family Children's Hospital, University of Iowa, Iowa City, Iowa, United States

ARTICLE INFO

Article history:
Received 29 March 2016
Received in revised form 14 June 2016
Accepted 8 December 2016
Available online 16 December 2016

Keywords:
All-terrain vehicles
Occupational safety
Injury prevention
Agriculture
Safety training

ABSTRACT

Introduction: Although all-terrain vehicles (ATVs) are very popular in rural areas for both recreation and work purposes, the epidemiology of agricultural ATV use remains largely unknown. *Methods:* Farm Progress Show attendees in 2012 (Boone, Iowa) and 2013 (Decatur, Illinois) were surveyed about ATVs, including riding behaviors, crash history, and safety knowledge. Descriptive and comparative analyses were performed (N = 635 surveys). *Results:* Over half of those surveyed lived on a farm and more than 90% had ridden on an ATV. Sixty-one percent rode at least once a week and 39% reported riding almost daily. Males and respondents who lived on farms were significantly more likely to be ATV riders. Regarding unsafe behaviors, >80% of ATV users had ridden with a passenger, 66% had ridden on a public road, and nearly one-half never or almost never wore a helmet. Nearly 40% reported having been in a crash. Multivariable logistic regression analysis of adult respondent's data showed males and younger adults were both more likely to report having crashed. In addition, those reporting riding on public roads (but not having ridden with passengers) were nearly five times more likely and respondents who reported both riding on public roads and having ridden with passengers were approximately eight times more likely to have been in a crash as compared to those not reporting these unsafe behaviors. Safety knowledge did not necessarily correspond with safer behaviors; 80% who knew there should be no passengers on an ATV still had ridden with extra riders. *Conclusion:* ATV use is prevalent in rural populations and most riders report engaging in unsafe riding behaviors. *Practical applications:* These findings may be used to inform ATV safety education and training programs targeted toward agricultural communities, with the goal of reducing occupational ATV-related deaths and injuries and their substantial economic costs.

1. Introduction

About 800 deaths and more than 400,000 injuries from all-terrain vehicle (ATV) crashes occur in the United States each year (U.S. Consumer Product Safety Commission, 2015). Although many ATV-related deaths and injuries occur during recreational riding, occupational use can also be hazardous. A study by the Bureau of Labor Statistics found that adult work-related deaths from ATV crashes rose nearly 400% from 1998 to 2007 (Helmkamp, Marsh, & Aitken, 2011). The highest fatality rate was among agricultural workers, 5.73 deaths per million workers per year. This death rate may be significantly underestimated, as both exposed and non-exposed workers were included in the denominator. A United States Department of Agriculture (USDA) survey showed that there were about 1.6 million ATVs on an estimated 2.2 million farms in 2011 with the vast majority being used for work purposes (Agricultural Statistics Board, 2013).

A number of vehicle design characteristics make ATVs prone to loss of control with resulting rollovers or collision events. These include a high center of gravity, low-pressure knobby tires, and lack of a rear differential. Because of these design features, ATV operation involves "active riding," defined as the timely shifting of the operator's body in response to changes in the vehicle's center of mass. Continuous assessment and good reflexes are needed to effectively manage uneven, inclined, and unexpected changes in terrain. Current models can weigh up to 800 lbs and travel at highway speeds, and larger, faster machines are involved in a growing proportion of ATV-related fatalities (Denning, Harland, Ellis, & Jennissen, 2013; Denning, Harland, & Jennissen, 2014).

Abbreviations: aOR, adjusted odds ratio; ATV, all-terrain vehicle; CI, confidence intervals; NIOSH, National Institute of Occupational Safety and Health; OR, unadjusted odds ratio; USDA, United States Department of Agriculture.

* Corresponding author at: Department of Emergency Medicine, 1008 Roy Carver Pavilion, 200 Hawkins Drive, University of Iowa Hospitals and Clinics, Iowa City, IA 52242, United States.
E-mail address: charles-jennissen@uiowa.edu (C.A. Jennissen).

http://dx.doi.org/10.1016/j.jsr.2016.12.001
0022-4375/

Previous survey studies examined youth exposure, riding habits and crash outcomes (Burgus, Madsen, Sanderson, & Rautiainen, 2009; Campbell et al., 2010; Hafner, Hough, Getz, Whitehurst, & Pearl, 2010; Hendricks, Myers, Layne, & Goldcamp, 2005; Jennissen, Harland, et al., 2014; Williams et al., 2011), and one study looked at ATV owning households (Rodgers, 1999). To our knowledge, no surveys have been done focusing on adult ATV users, and the epidemiology of agricultural-related use in the United States is largely unknown. To address this question, we surveyed participants at a large agricultural show to determine characteristics and outcomes of their ATV use and to assess their basic ATV-related safety knowledge.

2. Methods

2.1. ATV survey

Study participants were recruited during their visit to an ATV safety booth at the 2012 (Boone, Iowa) and 2013 (Decatur, Illinois) Farm Progress Show, the nation's largest outdoor farm show (Farm Progress Show, 2016). Participants were administered a survey which collected basic demographic data, ATV exposure, safety practices, and ATV-related knowledge. An ATV was defined as a vehicle with low-pressure tires, a straddle seat and handlebars for steering, and a picture of an ATV was provided for survey participants. Questions related to side-by-side vehicles such as utility task vehicles (UTVs) and recreational off-highway vehicles (ROVs) were not included in the study. Table 1 provides survey questions and potential responses. The survey was administered as a paper copy or responses were collected electronically using the TurningPoint™ audience-response system (https://www.turningtechnologies.com/). The authors' Institutional Review Board (IRB) deemed this study exempt.

2.2. Inconsistent exposure responses

Ideally, respondents not exposed to ATVs would have answered 'Never' to the question 'How often do you drive or ride on an ATV?' and then 'Never been on an ATV' for subsequent safety behavior questions. However, inconsistent responses to these questions were sometimes observed. As the most conservative approach for determining exposure, we considered those answering 'Never' for the riding frequency question unexposed. Subsequent answers inconsistent in this respect (27 of 635 surveys, 4.3%) were not included in further analysis of questions regarding ATV safety behavior. Those who did not answer the exposure question were also excluded from further analysis related to exposure (9 of 635 surveys, 1.4%).

Table 1
Farm Progress Show ATV safety survey.

Demographics
1. How old are you?
Answers: <6, 6–12, 13–15, 16–20, 21–30, 31–65, >65
2. What is your sex?
Answers: Male, Female
3. Where do you live?
Answers: On a farm, In the country but not on a farm, In town
ATV Knowledge
1. Most ATVs are made to carry how many people?
Answers: 1, 2, More than 3, I don't know
2. According to previous guidelines, what is the largest ATV engine size recommended for use by 12–15 year olds?
Answers: Under 70 cc, 90 cc, 200 cc, 300 cc, I don't know
3. According to Iowa law, when can someone ride an ATV on a public road?
Answers: When it is a gravel road, For farming purposes, You can never operate an ATV on public roads, I don't know
ATV Riding Practices
1. How often do you drive or ride on an ATV?
Answers: Almost daily, About once a week, About once a month, Only a few times a year or less, Never
For those who had ridden an ATV:
2. Have you ever ridden or driven an ATV with more than one person on the ATV?
Answers: Yes, No
3. Have you ever ridden or driven an ATV on a public road?
Answers: Yes, No
4. How often do you wear a helmet when riding an ATV?
Answers: *Always or almost always, More than half the time, Less than half of the time, Never or almost never*
5. Have you ever been in an ATV crash (rolled over, hit something, fallen off)?
Answers: Yes, No

2.3. Data analysis

Descriptive and comparative analyses were performed using SAS® software, Version 9.2 of the SAS System for Microsoft (SAS Institute Inc., Cary, NC, USA) or SPSS (IBM SPSS Statistics 22). Participant ages were grouped into 5 categories: <16, 16–20, 21–30, 31–65, and >65 years old. Comparisons of categorical variables were completed using the chi-square test. To determine the unadjusted odds ratios (OR) and 95% confidence intervals (95% CI) for 2 × 2 comparisons, we performed the chi square test on the Vassar statistics website (http://vassarstats.net/). All p-values shown are for a two-sided test and significance was defined as $p < 0.05$. Multivariable logistic regression analysis was used to calculate adjusted odds ratios (aOR) and 95% CI for dichotomous outcome variables, after controlling for covariates. Covariates for inclusion in the model were selected a priori based on previous knowledge and on results from bivariate analysis. Respondents with missing data for one or more of the variables used in the regression model were not included in multivariable analysis.

3. Results

3.1. Demographics

Of the 635 surveys completed, 64% of respondents were males, 80% were 16 years of age or older, and more than half lived on a farm (Table 2). Among survey participants, 90% reported having ridden on an ATV (i.e. were exposed). A higher proportion of males were exposed as compared to females (OR 4.15, 95% CI 2.30–7.49, $p < 0.0001$). In addition, there was no significant difference in exposure when comparing youth and adults. However, a lower percentage of respondents over 65 years of age reported having ridden on an ATV relative to younger adults, 16–65 years old (82% vs. 92%, OR 0.41, 95% CI 0.20–0.83, $p = 0.012$). In addition, differences in adult ATV exposure were seen based on where the respondent lived, with the highest exposure among participants living on farms (94%).

Table 2
Demographics of survey respondents and comparison of respondents reporting having ridden on an ATV (exposed) versus not (unexposed).

Variable	All respondents (N = 635)[2]	Exposed (N = 571)[2]	Unexposed (N = 55)[2]	p-Value[1]
	n (Col%)	n (Row %)	n (Row %)	
Sex				
Male	401 (64%)	380 (95%)	18 (5%)	<0.0001
Female	229 (36%)	188 (84%)	37 (16%)	
Youth vs. adults				
<16 years old	129 (20%)	121 (95%)	6 (5%)	0.07
≥16 years old	506 (80%)	450 (90%)	49 (10%)	
Adult age range				
16–20 years old	92 (15%)	85 (92%)	7 (8%)	
21–30 years old	63 (10%)	60 (95%)	3 (5%)	
31–65 years old	286 (45%)	252 (90%)	27 (10%)	
>65 years old	65 (10%)	53 (82%)	12 (18%)	
Residence				
On a farm	335 (53%)	315 (94%)	19 (6%)	0.0084
In country, not on farm	115 (18%)	102 (89%)	12 (11%)	
In town	179 (28%)	152 (86%)	24 (14%)	

[1] Chi square comparison of respondents exposed vs. not exposed to ATVs.
[2] The variable's column sum or row sum may not equal group N due to missing data.

3.2. Riding practices

Over 60% of those exposed to ATVs reported riding frequently (daily/weekly), 39% almost daily (Table 3). Overall, youth <16 years of age reported higher riding frequency than adults ($p = 0.023$), but three-fifths of adults still reported daily/weekly riding. Riding frequency was greater for adults living on farms as compared to other adult riders ($p < 0.0001$). In fact, over half of adults exposed to ATVs and living on farms reported riding almost daily and 75% reported riding at least once a week.

Over 80% of all respondents had ridden with more than one person on the ATV, and two-thirds had ridden on public roads. Nearly half reported never or almost never wearing a helmet, only 24% stated that they always or almost always used a helmet. Three-quarters reported practicing two or more of the following unsafe behaviors: riding with passengers, riding on public roads, and wearing a helmet less than half the time. A higher percentage of youth reported some helmet use as compared to adults ($p = 0.036$), but there was no difference between youth and adults when comparing riding with passengers or on public roads. A higher proportion of adults reported all three unsafe behaviors (44%) versus those <16 years of age (29%).

Differences in riding frequency and safety practices were observed among adults based on where they lived. Adult riders living on farms had higher riding frequencies than their peers whose residence was not on a farm ($p < 0.0001$). As compared to adults living in the country, a lower proportion of ATV riders from town reported riding with passengers ($p = 0.017$) or riding on public roads ($p = 0.0008$). Still, nearly three-quarters and over half of those living in towns reported riding with passengers and on public roads, respectively.

Significant differences were also noted regarding helmet use and where a respondent lived ($p = 0.0003$), with those living in town having the highest proportion for always/almost always wearing a helmet when on an ATV (32%). Overall, adults who lived on farms had the highest percentage reporting having ridden with passengers (84%), having ridden on public roads (73%), never or almost never wearing a helmet (58%), and of practicing all three unsafe riding behaviors (53%).

3.3. ATV safety knowledge

Participants were asked three ATV knowledge-related questions (Table 4). Four-fifths knew that most ATVs are made to carry only one person. However, less than two-fifths were aware that, according to previous guidelines, children 12–15 years of age were recommended to drive only ATVs with engine sizes of 90 cm^3 (cc) and less. Almost one-half correctly answered that, according to Iowa law, riding on public roadways is allowed for farming purposes.

There were differences in the proportion of correct answers for some questions based on demographics. There was a higher proportion of males as compared to females who correctly answered the question related to proper engine size for children 12–15 years of age (OR 1.74, 95% CI 1.23–2.47, $p = 0.0019$), but the percentage answering correctly was still only 42%. Adults more frequently knew ATVs should not have passengers as compared to youth (OR 2.27, 95% CI 1.46–3.53, $p = 0.0004$). Respondents living on farms or in the country more frequently knew one could ride on public roadways if conducting farm work in Iowa, as compared to those living in town (outside vs. inside town, OR 1.56, 95% CI 1.09–2.23, $p = 0.015$), but the percentage with correct answers was still less than 50%. Those with ATV exposure answered the engine size (OR 5.15, 95% CI 2.17–12.3, $p < 0.0001$) and riding on road (OR 3.85, 95% CI 1.90–7.84, $p = 0.0001$) questions correctly more often than those with no exposure, but still less than half of riders answered each question accurately. Safety knowledge did not necessarily correspond with safer riding behaviors. For example, of those who got the passenger question correct, 81% (372 of 460) still reported that they had ridden with passengers–a proportion that was not different than those who answered the question incorrectly (80%, 92 of 118, $p = 0.48$).

3.4. Crash experience

Nearly 40% of ATV riders reported having been in a crash, defined as rolling over, hitting something or having fallen off the ATV (Table 5). A significantly higher percentage of males had been in a crash as

Table 3
Riding practices among survey respondents exposed to ATVs. Comparisons shown are for youth (<16 years old) versus adults (≥16 years old) and by where the respondent lived for adult riders only.

Variable	All riders			p-Value[1]	Adult riders only			p-Value[2]
	All riders (N = 571) n (Col%)[3]	Youth (N = 123) n (Col%)[3]	Adults (N = 457) n (Col%)[3]		On a farm (N = 271) n (Col%)[3]	In country, not on farm (N = 79) n (Col%)[3]	In town (N = 152) n (Col%)[3]	
Riding frequency								
Almost daily	220 (39%)	50 (41%)	170 (38%)	0.023	130 (52%)	22 (32%)	17 (13%)	<0.0001
About once a week	127 (22%)	30 (25%)	97 (22%)		59 (23%)	15 (22%)	22 (17%)	
About once a month	67 (12%)	20 (17%)	47 (10%)		19 (8%)	9 (13%)	19 (15%)	
A few times a year or less	157 (28%)	21 (17%)	136 (30%)		44 (17%)	23 (33%)	69 (54%)	
Ridden with passengers								
Yes	459 (82%)	104 (87%)	353 (80%)	0.10	205 (84%)	57 (84%)	90 (72%)	0.017
No	102 (18%)	15 (13%)	86 (20%)		39 (16%)	11 (16%)	35 (28%)	
Ridden on public roads								
Yes	368 (66%)	78 (67%)	289 (66%)	1.0	177 (73%)	46 (68%)	69 (53%)	0.0008
No	190 (34%)	39 (33%)	149 (34%)		66 (27%)	22 (32%)	60 (47%)	
Wear helmet								
Always/almost always	132 (24%)	36 (29%)	104 (23%)	0.036	44 (18%)	17 (23%)	42 (32%)	0.0003
More than half the time	89 (16%)	27 (22%)	65 (14%)		29 (12%)	17 (23%)	18 (14%)	
Less than half the time	73 (13%)	13 (11%)	63 (14%)		30 (12%)	15 (21%)	18 (14%)	
Never/almost never	264 (47%)	47 (38%)	224 (49%)		144 (58%)	24 (33%)	55 (41%)	
Unsafe behaviors[4]								
None	46 (8%)	4 (3%)	36 (8%)	0.0007	13 (6%)	4 (6%)	19 (15%)	0.0004
One	95 (17%)	23 (20%)	72 (17%)		33 (14%)	12 (18%)	26 (21%)	
Two	185 (34%)	55 (48%)	130 (30%)		65 (28%)	28 (42%)	37 (30%)	
Three	222 (41%)	33 (29%)	189 (44%)		125 (53%)	23 (34%)	41 (33%)	

[1] Chi square comparison of youth vs. adults.
[2] Chi square comparison of farm vs. country, not a farm vs. town.
[3] The variable's column sum may not equal group N due to missing data.
[4] The three unsafe behaviors were having ridden with passengers, having ridden on public roads, and wearing a helmet less than half the time (including never/almost never).

Table 4
Results of ATV knowledge questions for all survey respondents. N = 635.

Variable	Most ATVs are made to carry how many people? Answer: One			What is the largest ATV engine size previously recommended for 12–15 year olds? Answer: 90 cc			When can one legally ride an ATV on a public road according to Iowa law? Answer: For farming purposes		
	Correct (N = 493) (80%)[2]	Incorrect (N = 127) (20%)[2]	p-Value[1]	Correct (N = 229) (37%)[2]	Incorrect (N = 390) (63%)[2]	p-Value[1]	Correct (N = 281) (46%)[2]	Incorrect (N = 336) (54%)[2]	p-Value[1]
	n (Row%)[3]	n (Row%)[3]		n (Row%)[3]	n (Row%)[3]		n (Row%)[3]	n (Row%)[3]	
Sex									
Male	316 (80%)	78 (20%)	0.81	163 (42%)	229 (58%)	0.0019	189 (48%)	202 (52%)	0.086
Female	177 (79%)	47 (21%)		65 (29%)	159 (71%)		91 (41%)	132 (59%)	
Youth vs. adults									
<16 years old	83 (67%)	40 (33%)	0.0002	50 (40%)	74 (60%)	0.45	56 (46%)	67 (54%)	0.92
≥16 years old	410 (82%)	87 (18%)		179 (36%)	316 (64%)		225 (46%)	269 (54%)	
Residence									
On a farm	270 (82%)	58 (18%)	0.23	119 (37%)	207 (63%)	0.79	161 (49%)	165 (51%)	0.043
In country, not on farm	88 (78%)	25 (22%)		45 (39%)	69 (61%)		52 (46%)	61 (54%)	
In town	135 (76%)	42 (24%)		63 (36%)	114 (64%)		66 (38%)	109 (62%)	
Ridden on an ATV									
Yes	449 (80%)	113 (20%)	0.79	223 (40%)	339 (60%)	<0.0001	268 (48%)	292 (52%)	0.0001
No	41 (77%)	12 (23%)		6 (11%)	47 (89%)		10 (19%)	42 (81%)	

[1] Chi square comparison of correct vs. incorrect response.
[2] All respondents (Row%)
[3] The variable's row sum might not equal total group N due to missing data

compared to females (OR 3.04, 95% CI 2.03–4.57, p < 0.001), but there were no differences by age or by residence. There were, however, significant differences in the percentage of respondents who had been in a crash based on their reported riding frequency. A fairly consistent increase in reporting having been in a crash was seen with increasing riding frequency. Daily/almost daily riders had the highest reported percentage of having been in at least one crash, which was over half of these frequent riders.

Respondents who affirmed engaging in risky riding practices that could contribute to a crash (i.e. riding with passengers and/or on public roads), had significantly higher percentages reporting having been in a crash. Over 8 out of 10 who engaged in both unsafe practices reported having crashed.

Table 5
Characteristics related to ever having been in an ATV crash for all survey respondents exposed to ATVs. N = 635.

Variable	Been in a crash[1]		p-Value[2]
	Yes (N = 213) (38%)[3]	No (N = 342) (62%)[3]	
	n (Row %)[4]	n (Row %)[4]	
Sex			
Male	173 (47%)	199 (53%)	<0.0001
Female	40 (22%)	140 (78%)	
Youth vs. adults			
<16 years old	49 (41%)	71 (59%)	0.53
≥16 years old	164 (38%)	271 (49%)	
Riding frequency			
Almost daily	114 (54%)	99 (46%)	<0.0001
About once a week	51 (40%)	75 (60%)	
About once a month	23 (35%)	43 (65%)	
A few times a year or less	25 (17%)	125 (83%)	
Residence			
On a farm	122 (40%)	182 (60%)	0.38
In country, not on farm	41 (41%)	60 (59%)	
In town	50 (34%)	98 (66%)	
Ridden with passengers			
Yes	195 (43%)	258 (57%)	<0.0001
No	17 (18%)	79 (82%)	
Ridden on road			
Yes	183 (50%)	182 (50%)	<0.0001
No	29 (16%)	155 (84%)	
Unsafe riding practices[5]			
Neither practice	6 (3%)	56 (17%)	<0.0001
Riding with passengers	23 (11%)	97 (29%)	
Riding on road	11 (5%)	21 (6%)	
Both practices	171 (81%)	158 (48%)	

[1] A crash was defined as rolling over, hitting something or having fallen off the ATV.
[2] Chi square comparisons of reporting having been in a crash (Yes) vs. not (No).
[3] All respondents (Row%).
[4] The variable's row sum might not equal total group N due to missing data.
[5] The two individual unsafe riding practices were having ridden with passengers and having ridden on public roads.

Table 6
Multivariable logistic regression analysis for outcome of ever having been in a crash versus not for adult survey respondents exposed to ATVs.

Variable	Adult respondents[1]	
	aOR	95% CI
Sex		
Male	2.23	1.32–3.77
Female	1.0 (ref)	
Age range		
16–20 years old	1.95	1.09–3.51
21–30 years old	2.14	1.12–4.11
31–65 years old	1.0 (ref)	
>65 years old	0.58	0.26–1.33
Riding frequency		
Almost daily	3.59	1.83–7.05
About once a week	2.23	1.12–4.46
About once a month	2.04	0.86–4.82
A few times a year or less	1.0 (ref)	
Residence		
On a farm	0.70	0.39–1.26
In country, not on farm	0.90	0.43–1.89
In town	1.0 (ref)	
Unsafe riding practices[2]		
Neither practice	1.0 (ref)	
Riding with passengers	2.61	0.84–8.09
Riding on the road	4.83	1.23–18.93
Both practices	8.02	2.93–21.96

[1] N = 426 adult respondents included in the model. Remaining adult cases not included due to missing data for one or more covariables in the model.
[2] The two individual unsafe practices included in the model were having ridden with passengers and having ridden on public roads.

3.5. Multivariable regression analysis for adults having been in a crash

A multivariable logistic regression analysis of data from adult survey respondents (N = 426) was done to determine the factors that were associated with the likelihood of reporting having had at least one ATV crash, while controlling for co-variables (Table 6). Males, as compared to females, were more than twice as likely to have had a crash. Similarly, younger adults 16–20 years and 21–30 years were both about two times more likely to have been in a crash as compared to older adults who were 31–65 years of age. Daily riders were over 3.5 times more likely and weekly riders were over twice as likely to report having been in at least one crash as compared to those who reported riding a few times a year or less.

There was no association between the likelihood of reporting having been in a crash and where respondents lived. However, those who reported riding on public roads (but not having ridden with passengers) were nearly five times more likely and respondents who reported both riding on public roads and having ridden with passengers were approximately eight times more likely to report having been in at least one ATV crash as compared to those not reporting these unsafe behaviors.

4. Discussion

4.1. Occupational ATV use

Although the first ATVs to reach the U.S. market were marketed as recreational vehicles, people were quick to realize that these vehicles could perform important work-related tasks especially in agriculture. In 1982, Honda introduced a 192 cm^3 engine model marketed for occupational chores including towing, spraying, seeding and fertilizing (Burch, 2007). Since then, occupational ATV use has continued to grow, but has only achieved a significant presence in the U.S. workplace in the past 15 years or so (Helmkamp et al., 2011).

A major factor in ATVs popularity has been their rapid increase in size, power, and speed. Almost all vehicles sold in the mid-late 1990's had engine displacements of 350 cm^3 or less. In just a few years, a marked shift in the size of vehicles manufactured and sold took place (Murphy & Yanchar, 2004). Although current sales data is not readily available, the vehicles available on ATV dealer showrooms have gotten significantly bigger, as have the vehicles involved in ATV-related deaths over the past decade (Denning, Harland, et al., 2013).

The greater size and power of ATVs have been particularly welcomed in work settings, and many after-market products have become available which have increased their work utility. A survey of ATV owners in 2008 by the Motorcycle Industry Council found that nearly a quarter used their ATV for work or chores (General Accounting Office, 2010), while a telephone survey of 25,000 farmers in 2011 found that almost 90% of the ATVs on farms were used for work-related tasks at least some of the time (Agricultural Statistics Board, 2013).

Common contributing factors for ATV crashes and injuries include high speeds, lack of helmet use, driving on roads, lack of adequate training, carrying passengers, and substance use (Denning, Harland, et al., 2013; Denning, Jennissen, Harland, Ellis, & Buresh, 2013; General Accounting Office, 2010; Levenson, 2003; Rodgers, 2008). According to the Occupational Safety and Health Administration, workers using ATVs are exposed to similar hazards as recreational riders (Occupational Safety and Health Administration Safety and Health, 2006). The majority of occupational deaths have been in the agriculture/forestry/fishing/hunting industry sector (Helmkamp et al., 2011). However, almost one-third have occurred in a variety of other industries.

Occupational injuries and deaths exert a huge societal economic burden and those that are ATV-related are no different. Using a cost-of illness model developed by the NIOSH Division of Safety Research, the mean lifetime cost of each occupational ATV-related fatality from 2003 to 2006 was $803,100 and the median cost was $772,100 in 2006 dollars (Helmkamp, Biddle, Marsh, & Campbell, 2012). Of course, many more workers receive non-fatal injuries than die from ATV-related events, and these occupational injuries are a critical component of the overall economic cost.

4.2. ATV exposure

Our study found that 9 of 10 survey respondents at the Farm Progress Shows in 2012 and 2013 had been on an ATV. Few studies have focused on adult ATV users, but four-fifths of our participants were ≥16 years of age with nearly two-thirds 21 years and older. A study of Iowa primary healthcare providers (N = 218) found that 53% had previously been on an ATV (Jennissen, Denning, Sweat, Harland, & Buresh, 2012). This was a significantly lower percentage than our study population. However, previous studies of select rural youth groups have found similarly high rates of ATV exposure including 99% of children surveyed at Connecticut agricultural fairs (Campbell et al., 2010), and 97% of teenage attendees at a national Future Farmers of America convention (Burgus et al., 2009). Other studies have found 44% of Illinois 4-H club members having ridden an ATV in the previous one-half year (Hafner et al., 2010), and 59% of Arkansas teens attending an agricultural program had ridden an ATV in the past month (Jones & Bleeker, 2005).

A study of more than 3600 Iowa school children 11–16 years of age from both urban and rural settings found that over three-quarters had been on an ATV with nearly two-fifths reporting riding at least weekly (Jennissen, Harland, et al., 2014). However, the students from isolated rural settings had about a 1.4 times greater likelihood of ATV exposure as those from urban settings. In the current study, Farm Progress Show survey participants who lived in the country (on a farm or other rural residence) had higher proportions reporting ATV use as compared to those living in a town, with the highest percentage of ATV exposure among respondents who lived on farms. In fact, three-quarters of those living on farms reported riding ATVs at least weekly.

4.3. Riding with passengers

Almost all ATVs are designed for a single rider and all vehicles have warning labels clearly stating this. Carrying passengers on ATVs is a known risk factor for crash and injury. Consumer Product Safety Commission ATV fatality data shows that from 1985 to 2009, almost 30% of all deaths in the United States were passengers or operators with passengers on the vehicle at the time of the crash (Denning, Harland, et al., 2013). The vast majority of our study respondents exposed to ATVs had ridden with more than one person. Of those ATV riders who lived on farms, 84% reported having ridden with passengers. Other studies have found similarly high percentages having ridden with passengers, ranging from 50 to 90% (Burgus et al., 2009; Campbell et al., 2010; Hafner et al., 2010; Jennissen, Harland, et al., 2014; Jones & Bleeker, 2005). The vast majority of participants in the study were aware that ATVs were to be used by an operator only, but knowledge did not seem to affect safety behavior practice. Those respondents who answered the passenger question correctly had the same proportion reporting having ridden with multiple riders as those who answered it wrong.

Passengers can prevent the “active riding” required to maintain control of the vehicle, as well as distract the driver and interfere with steering. Moreover, extra riders may increase the odds of specific crash and injury mechanisms. In a study of ATV-related trauma patients, the odds of a backward rollover were 2.5 times higher compared to other rollovers and the odds of having been ejected to the rear were more than 5 times higher compared to other ejections when extra riders were present (Jennissen, Harland, Wetjen, & Denning, 2016). Victims who were ejected to the rear had the highest mean head injury scores, possibly due to a decreased ability to protect the head with an outstretched hand as one might attempt during a side ejection. In

addition, ATV victims in a collision with a motor vehicle had a 2.5 times greater odds of having been carrying passengers on the ATV than victims in other types of crashes.

Although specified as single-rider vehicles, the lengths of ATV seats on adult size vehicles vary considerably (Jennissen, Miller, Tang & Denning, 2014). Many are long enough to accommodate an extra rider, something that could encourage carrying passengers, especially among youth. In addition, the distance from the front of the seat to the handle grips is often shorter on ATVs with longer seats (Jennissen, Miller, et al., 2014). This may allow smaller children to operate vehicles that are far too large, powerful and fast for them to safely ride. Employers and families need to adopt and enforce strict, no-passenger rules to prevent the risks associated with extra riders on ATVs. Moreover, industry-wide standards for ATV seat length and placement should be implemented that allows active riding but would significantly decrease, if not eliminate, the likelihood of passengers sharing the seat.

4.4. Riding on the road

ATVs are not designed for roadway use. More than 60% of ATV-related deaths in the United States have been on roadways, and roadway crash fatalities have increased at over twice the rate of those off-road since 1998 (Denning, Harland, et al., 2013; Helmkamp, 2003). Two-thirds of respondents in our study reported having ridden on a public road with no difference observed in the percentage of roadway riding between youth and adults. In the Iowa school-based study, slightly over 80% reported having ridden on a public road (Jennissen, Harland, et al., 2014). General roadway use has been similarly high in other reports, with use on paved roads being somewhat lower (Burgus et al., 2009; Rodgers, 1999).

As compared to town dwellers in our study, those who lived on farms or in the country had a higher percentage that reported having ridden on a public road and also had a greater proportion that knew one could legally use an ATV on a public road for farming purposes in Iowa. Nearly three-quarters of those who lived on farms reported having ridden on a road, and many may have done so, at least at times, while performing agricultural-related tasks.

Many ATV riders on unpaved roads may have a false sense of security since these roads are often less traveled. However, over 40% of all U.S. public roadway deaths have occurred on unpaved roadway surfaces (Denning & Jennissen, 2015). Although collisions with other motor vehicles are a problem, the vast majority of all U.S. roadway fatalities do not involve another vehicle (Denning, Harland, et al., 2013; Denning & Jennissen, 2015).

Since ATVs are designed for off-road terrains, they have multiple features that place riders at increased risk of losing control when driving on public roads and this risk is exacerbated by the higher speeds achievable on roadway surfaces. Farmers should avoid driving ATVs on roadways for occupational purposes whenever possible. If they plan to use ATVs on roadways, farmers should consider purchasing vehicles that are orange or yellow in color, and always have a fluorescent orange flag displayed at least 5 ft above the ground on the vehicle to make one more visible to other roadway users. Farmers need to be aware of the increased dangers if they elect to use an ATV on public roads for work, and take proper safety precautions such as riding alone, maintaining a lower speed, and wearing a helmet.

4.5. Helmet use

One of the leading causes of death and disability from ATV crashes is injury to the head (Bhutta, Greenberg, Fitch, & Parnell, 2004; Bowman, Aitken, Helmkamp, Maham, & Graham, 2009; Brandenburg, Brown, Archer, & Brandt, 2007). Helmet use has been found to decrease the likelihood of fatal ATV crash-related brain injury by 40% and nonfatal brain injuries by 60% or more (Bowman et al., 2009; Denning, Harland, et al., 2013; Denning, Jennissen, et al., 2013; Merrigan, Wall, Smith, Janus, & Sidwell, 2011; Myers, Cole, & Mazur, 2009). Despite this, respondents in the study reported low use of helmets, with less than a quarter reporting they always/almost always used head protection and nearly one-half reporting they never/almost never wore a helmet. This is similar to the helmet use practiced by Iowa school-aged children where the majority never or almost never wore a helmet and less than one-fifth reported wearing one routinely (Jennissen, Harland, et al., 2014). Both of these helmet use rates are consistent with that observed in studies of ATV-related trauma patients (Denning, Harland, et al., 2013; Denning, Jennissen, et al., 2013; Hall, Bixler, Helmkamp, Kraner, & Kaplan, 2009; Helmkamp, 2003).

Farmers may have an even lower helmet use while driving ATVs then other groups. Survey respondents living on farms had the highest percentage that never/almost never wore a helmet (58%) and the lowest proportion that always/almost always did (18%). Farmers need to be encouraged to wear head protection while riding on ATVs. There may be alternative head gear to traditional ATV and motorcycle helmets that would provide protection but be more acceptable to farmers when performing off-road occupational tasks (QuadSafe Australia, 2014).

4.6. ATV crashes

About two-fifths of ATV-riding respondents had been in at least one crash, and there was no difference in the proportions when comparing youth with adults. Previous studies of young people with ATV exposure found that 44% of child attendees of Connecticut agricultural fairs, 57% of Iowa school children, and 67% of Illinois 4-H club members had experienced a crash event (Campbell et al., 2010; Hafner et al., 2010; Jennissen, Harland, et al., 2014). In our study, there was no significant difference in the percentage that had experienced a crash based on where survey participants lived. Similarly, Iowa students from isolated rural, rural, or urban school districts had similar likelihoods of having had a crash (Jennissen, Harland, et al., 2014).

However, our study did identify populations with different likelihoods of having been in an ATV crash. Since most previous reports concentrated on ATV crashes among youth, we decided to perform our multivariable logistic regression analysis on only respondents 16 years of age and older in order to identify contributors to adult crashes. We found adult males were over twice as likely as females to have had a crash. This was similar to the Iowa school children study in which males were over 1.5 times more likely than females to have crashed on an ATV (Jennissen, Harland, et al., 2014). Of course, more frequent riders had a greater likelihood of having had a crash; the likelihoods of adults in our study being very similar to that seen in Iowa school children for different degrees of riding frequency (Jennissen, Harland, et al., 2014). Our study also showed that respondents 16–30 years of age were about twice as likely of having had an ATV crash as compared to adults 31–65 years old.

A high percentage of ATV riders in our study reported engaging in unsafe riding behaviors with three-quarters reporting at least two of the following: riding with passengers, riding on public roads, and wearing a helmet less than half the time. Those living on farms had the highest percentages reporting unsafe riding behaviors, and over half of farm residents reported engaging in all three of the unsafe behaviors included in our study. The presence of multiple risk factors has been shown to increase the likelihood and severity of ATV-related crashes (Jennissen, Harland, et al., 2014; Rodgers, 2008). After controlling for other variables in our study, those who rode on public roads (but did not report riding with passengers) had a nearly five times greater likelihood, and those who practiced both riding on public roads and riding with passengers had an 8 times greater likelihood of having had a crash, as compared to those who reported neither unsafe riding behavior.

5. Limitations

Our study consists of a convenience sample of attendees at a large agricultural show and is not a randomized sampling of a designated population. This limits the generalizability of our results. However, very little is known about the ATV riding behaviors of adults, and the epidemiology of rural and agricultural ATV use is limited. Our study helps to fill some of that knowledge gap.

Social desirability bias could have affected our results as is possible for any study using self-reported data. However, one would expect this bias, if present, to have decreased the reporting of unsafe ATV riding behaviors not increased it. The survey was completed anonymously, which should have helped decrease the likelihood of this bias.

6. Summary

We found that ATV use is prevalent among rural populations attending a major agricultural show, but many riders reported unsafe riding behaviors and having been in a crash. Those who lived on farms had higher proportions reporting unsafe riding behaviors, and those reporting unsafe riding practices had a greater likelihood of having had a crash. Survey participants also had limited safety knowledge. Study and input from rural community members and agricultural producers is essential for defining the scope of the problem and for designing ATV safety education and training programs that effectively target agricultural populations.

7. Practical implications

Results from this survey study will be incorporated into ATV safety education and training programs targeted to agricultural communities and focusing on occupational safety. They also contribute to the body of evidence that demonstrates the importance of implementing engineering-based solutions and the passage of legislation designed to decrease unsafe riding behaviors. In this respect, our study found that respondents knowing most ATVs are for an operator only did not decrease their likelihood of being on ATVs with multiple riders. Other approaches, such as standardizing ATV seat design to discourage multiple riders and the passage of legislation prohibiting passengers on ATVs, are likely necessary to improve ATV-related safety and prevent injuries. Other laws supported by the study results include those requiring helmet use and those restricting public roadway riding. Together, these cross-disciplinary approaches will contribute to our long-term goal of reducing both occupational and recreational ATV-related deaths and injuries and their substantial personal and economic costs.

Acknowledgements

Primary funding was provided by a grant to the University of Iowa Stead Family Children's Hospital from Kohl's Cares, a program of Kohl's Department Stores that supports kids' health and education initiatives nationwide. Support was also provided by the Emergency Medicine department and the Pediatric Surgery division at the University of Iowa Hospitals and Clinics. We would like to acknowledge other groups and individuals who are members and supporters of the Iowa ATV Injury Prevention Task Force for their contributions to this study.

References

Agricultural Statistics Board (2013). U.S. Department of Agriculture (USDA)National Agricultural Statistics Service (NASS) 2011 Farm and Ranch Safety Survey. Available at: http://usda.mannlib.cornell.edu/usda/current/FarmSafe/FarmSafe-05-30-2013.pdf (Accessed March 19, 2016).

Bhutta, S. T., Greenberg, S. B., Fitch, S. J., & Parnell, D. (2004). All-terrain vehicle injuries in children: injury patterns and prognostic implications. *Pediatric Radiology*, *34*(2), 130–133.

Bowman, S. M., Aitken, M. E., Helmkamp, J. C., Maham, S. A., & Graham, C. J. (2009). Impact of helmets on injuries to riders of all-terrain vehicles. *Injury Prevention*, *15*(1), 3–7.

Brandenburg, M. A., Brown, S. J., Archer, P., & Brandt, E. N., Jr. (2007). All-terrain vehicle crash factors and associated injuries in patients presenting to a regional trauma center. *The Journal of Trauma*, *63*(5), 994–999.

Burch, M. (2007). *The field & stream all-terrain vehicle handbook: complete guide to owning & maintaining an ATV*. Lyons Press. Globe Pequot Press Revised edition. (http://www.lyonspress.com).

Burgus, S. K., Madsen, M. D., Sanderson, W. T., & Rautiainen, R. H. (2009). Youths operating all-terrain vehicles—implications for safety education. *Journal of Agromedicine*, *14*(2), 97–104.

Campbell, B. T., Kelliher, K. M., Borrup, K., Corsi, J., Saleheen, H., Bourque, M. D., & Lapidus, G. (2010). All-terrain vehicle riding among youth: how do they fair? *Journal of Pediatric Surgery*, *45*(5), 925–929.

Denning, G., & Jennissen, C. (2015). All-terrain vehicle fatalities on paved roads, unpaved roads, and off-road: evidence for informed roadway safety warnings and legislation. *Traffic Injury Prevention*, *17*(4), 406–412 (ePrint Date June 11).

Denning, G., Harland, K., Ellis, D., & Jennissen, C. (2013a). More fatal all-terrain vehicle crashes occur on the roadway than off: increased risk-taking characterises roadway fatalities. *Injury Prevention*, *19*, 250–256.

Denning, G., Harland, K., & Jennissen, C. (2014). Age-based risk factors for pediatric ATV-related fatalities. *Pediatrics*, *134*(6), 1094–1102.

Denning, G., Jennissen, C., Harland, K., Ellis, D., & Buresh, C. (2013b). All-terrain vehicles (ATVs) on the road: a serious traffic safety and public health concern. *Traffic Injury Prevention*, *14*(1), 78–85.

Farm Progress Show (2016). Celebrating over 50 years of farm progress show success. Available at: http://farmprogressshow.com/customPage.aspx?p=200 (Accessed March 22, 2016)

General Accounting Office (2010). All-terrain vehicles: how they are used, crashes, and sales of adult-sized vehicles for children's use. 2010 report to congressional committees (GAO-10-418). Available at: http://www.gao.gov/new.items/d10418.pdf (Accessed March 23, 2016).

Hafner, J. W., Hough, S. M., Getz, M. A., Whitehurst, Y., & Pearl, R. H. (2010). All-terrain vehicle safety and use patterns in Central Illinois youth. *The Journal of Rural Health*, *26*(1), 67–72.

Hall, A. J., Bixler, D., Helmkamp, J. C., Kraner, J. C., & Kaplan, J. A. (2009). Fatal all-terrain vehicle crashes: injury types and alcohol use. *American Journal of Preventive Medicine*, *36*(4), 311–316.

Helmkamp, J. C. (2003). ATV-related deaths in West Virginia: 1990–2003. *West Virginia Medical Journal*, *99*(6), 224–227.

Helmkamp, J. C., Biddle, E., Marsh, S. M., & Campbell, C. R. (2012). The economic burden of all-terrain vehicle related adult deaths in the U.S. workplace, 2003–2006. *Journal of Agricultural Safety and Health*, *18*(3), 233–243.

Helmkamp, J. C., Marsh, S. M., & Aitken, M. E. (2011). Occupational all-terrain vehicle deaths among workers 18 years and older in the United States, 1992–2007. *Journal of Agricultural Safety and Health*, *17*(2), 147–155.

Hendricks, K. J., Myers, J. R., Layne, L. A., & Goldcamp, E. M. (2005). Household youth on minority operated farms in the United States, 2000: exposures to and injuries from work, horses, ATVs and tractors. *Journal of Safety Research*, *36*(2), 149–157.

Jennissen, C., Harland, K., Wetjen, K., Peck, J., Hoogerwerf, P., & Denning, G. (2014a). A school-based study of adolescent all-terrain vehicle exposure, safety behaviors, and crash experience. *Annals of Family Medicine*, *12*(4), 310–316.

Jennissen, C., Miller, N., Tang, K., & Denning, G. (2014b). Optimising seat design for all-terrain vehicle injury prevention: wide variability illustrates need for evidence-based standardisation. *Injury Prevention*, *20*(2), 88–96.

Jennissen, C., Denning, G., Sweat, S., Harland, K., & Buresh, C. (2012). All-terrain vehicle injury prevention: healthcare providers' knowledge, attitudes, and the anticipatory guidance they provide. *Journal of Community Health*, *37*(5), 968–975.

Jennissen, C., Harland, K., Wetjen, K., & Denning, G. (2016). The effect of passengers on all-terrain vehicle crash mechanisms and injuries. http://www.mdpi.com/2313-576X/2/1/1/pdf (Safety, ePrint Date January 20).

Jones, C. S., & Bleeker, J. (2005). A comparison of ATV-related behaviors, exposures, and injuries between farm youth and nonfarm youth. *The Journal of Rural Health*, *21*(1), 70–73.

Levenson, M. (2003). All-terrain vehicle 2001 injury and exposure studies. Consumer product safety commission report. Available at: http://www.cpsc.gov/library/foia/foia03/os/atvex2001.pdf (Accessed March 23, 2016).

Merrigan, T. L., Wall, P. L., Smith, H. L., Janus, T. J., & Sidwell, R. A. (2011). The burden of unhelmeted and uninsured ATV drivers and passengers. *Traffic Injury Prevention*, *12*(3), 251–255.

Murphy, N., & Yanchar, N. L. (2004). Yet more pediatric injuries associated with all-terrain vehicles: should kids be using them? *The Journal of Trauma*, *56*(6), 1185–1190.

Myers, M. L., Cole, H. P., & Mazur, J. M. (2009). Cost effectiveness of wearing head protection on all-terrain vehicles. *Journal of Agromedicine*, *14*(3), 312–323.

Occupational Safety and Health Administration Safety and Health (2006e). *OSHA, hazards associated with all-terrain vehicles (ATVs) in the workplace.* Washington, D.C.: U.S. Department of Labor, Occupational Safety and Health Administration Information Bulletin 08-03-2006. Available at: http://www.osha.gov/dts/shib/shib080306.html Accessed March 23, 2016)

QuadSafe Australia (2014). Farmers ATV helmet concept. Available at: http://www.quadsafeaustralia.com/news/farmers-atv-helmet-concept-2/ (Accessed March 23, 2016)

Rodgers, G. B. (1999). The characteristics and use patterns of all-terrain vehicle drivers in the United States. *Accident Analysis & Prevention*, *31*(4), 409–419.

Rodgers, G. B. (2008). Factors associated with the all-terrain vehicle mortality rate in the United States: an analysis of state-level data. *Accident Analysis & Prevention*, *40*(2), 725–732.

U.S. Consumer Product Safety Commission (2015). 2013 Annual report of ATV-related deaths and injuries. Available at: http://www.cpsc.gov//Global/Research-and-Statistics/Injury-Statistics/Sports-and-Recreation/ATVs/2013-ATV-Annual-Rpt-of-ATV-Related-Deaths–Injuries.pdf (Accessed March 23, 2016).

Williams, R. S., Graham, J., Helmkamp, J. C., Dick, R., Thompson, T., & Aitken, M. E. (2011). A trial of an all-terrain vehicle safety education video in a community-based hunter education program. *The Journal of Rural Health*, *27*(3), 255–262.

Charles A. Jennissen, MD, is a Clinical Professor in the Department of Emergency Medicine at the University of Iowa Carver College of Medicine. He completed medical school at the University of Minnesota and a residency in Pediatrics at the University of Iowa. He is board certified in Pediatrics and Pediatric Emergency Medicine. Most of Dr Jennissen's research has addressed injury prevention issues, especially related to ATV use. He grew up on a dairy farm and is particularly interested in agricultural work-related injuries.

Dr. Karisa K. Harland is an Associate Research Scientist in the University of Iowa Department of Emergency Medicine. Dr. Harland has a PhD in Epidemiology and is a NIOSH-trained Occupational Injury Epidemiologist with over 14 years of experience conducting and analyzing epidemiologic research studies. Before joining Emergency Medicine, Dr. Harland worked for the Injury Prevention Research Center and the Department of Epidemiology in the College of Public Health at the University of Iowa. Dr. Harland's research interests include epidemiologic methods, motor vehicle related crashes including ATVs, farm equipment and crashes among teens, and violence prevention.

Kristel Wetjen is the Pediatric Trauma Nurse Coordinator in the Division of Pediatric Surgery at the University of Iowa Stead Family Children's Hospital. She received her RN degree at the University of Iowa. She is a founding member of the Iowa ATV Injury Prevention Task Force and provides school-based ATV safety education through the Safety Tips for ATV Riders (STARs) Program. She provides other injury prevention outreach including bicycle safety and child car seat use.

Pamela Hoogerwerf is an Injury Prevention & Community Outreach Coordinator and the Director of the Safety Store at the University of Iowa Stead Family Children's Hospital. She graduated with a BA in Communication Studies from the University of Iowa. Ms. Hoogerwerf is a founding member of the Iowa ATV Injury Prevention Task Force and provides school-based ATV safety education through the Safety Tips for ATV Riders (STARs) Program. She has been very active in safety outreach related to bicycles, ATVs and child restraint use in motor vehicles.

Lauren O'Donnell is an Injury Prevention & Community Outreach Coordinator at University of Iowa Stead Family Children's Hospital. She graduated with a BA in Interdepartmental Studies from the University of Iowa. She is an active member of the Iowa ATV Injury Prevention Task Force and works on childhood injury prevention in a number of other areas including bicycle safety and the proper restraint of children in motor vehicles.

Gerene M. Denning, PhD, is a Research Scientist and former Director of Basic Science Research in the University of Iowa Department of Emergency Medicine. She completed an MS degree at the University of California at San Diego and a doctorate degree at the University of Iowa, both in Biochemistry. She has done basic science research at the Howard Hughes Medical Center, the VA Medical Center in Iowa City, and at the University of Iowa in the Departments of Internal Medicine and Emergency Medicine. Most recently, her research has concentrated on injury prevention, particularly related to ATVs and other off-road vehicles.