

Age Legislation and Off-Road Vehicle Injuries in Children

Michael R. Flaherty, DO,^{a,b} Toby Raybould, MS,^c Cassandra M. Kelleher, MD,^{b,d} Raghu Seethala, MD,^{b,e} Jarone Lee, MD, MPH,^{b,c} Haytham M.A. Kaafarani, MD, MPH,^{b,c} Peter T. Masiakos, MS, MD^{b,d}

abstract

BACKGROUND AND OBJECTIVES: In 2010, the Massachusetts Legislature passed a comprehensive law that restricted off-road vehicle (ORV) use by children <14 years old and regulated ORV use by children up to the age of 18 years. We aimed to examine the impact of the 2010 Massachusetts law on the rates of ORV-related injuries.

METHODS: A retrospective analysis was performed of Massachusetts emergency department (ED) and inpatient discharges between 2002 and 2013 as found in the Center for Health Information and Analysis database by using external causes of injury codes specific to ORV-related injuries. Yearly population-based rates were compared before and after the implementation of the law (2002–2010 vs 2011–2013) by using Poisson regression analysis and segmented regression.

RESULTS: There were 3638 ED discharges and 481 inpatient discharges for ORV-related injuries in children across the 12-year study period. After the implementation of the law, the rate of ED discharges declined by 33% in 0- to 9-year-olds, 50% in 10- to 13-year-olds, and 39% in 14 to 17-year-olds ($P < .0001$). There was no significant decline in ED discharges for 25- to 34-year-olds. Inpatient hospital discharges were also reduced by 41% in 0- to 17-year-olds after implementation ($P < .001$).

CONCLUSIONS: As compared with adults (ages 25–34 years), the population-based ORV-related injury rate of residents <18 years old significantly declined after the passage of legislation that imposed age restrictions and other safeguards for youth riders.

FREE

^aDepartment of Pediatric Critical Care Medicine, ^bDepartment of Surgery, Division of Trauma, Emergency Services, and Surgical Critical Care, and ^dDepartment of Pediatric Surgery, Massachusetts General Hospital, Boston, Massachusetts; ^cHarvard Medical School, Harvard University, Boston, Massachusetts; and ^eDepartment of Emergency Medicine, Brigham and Women's Hospital, Boston, Massachusetts

Dr Flaherty conceptualized and designed the study, coordinated the data collection and acquisition of data, analyzed and interpreted data, and drafted the initial manuscript; Mrs Raybould conceptualized and designed the study, coordinated the data collection and acquisition of data, and reviewed and revised the manuscript; Dr Kelleher analyzed and interpreted the data and reviewed and revised the manuscript; Dr Seethala conducted the initial analyses and reviewed and revised the manuscript; Drs Lee and Kaafarani conceptualized and designed the study and drafted the initial manuscript; Dr Masiakos conceptualized and designed the study, coordinated the data collection and acquisition of data, and drafted the initial manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

DOI: <https://doi.org/10.1542/peds.2017-1164>

Accepted for publication Jul 17, 2017

Address correspondence to Michael R. Flaherty, DO, Department of Pediatric Critical Care Medicine, Massachusetts General Hospital, 55 Fruit St, Boston, MA 02114. E-mail: mrflaherty@partners.org

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

WHAT'S KNOWN ON THIS SUBJECT: Off-road vehicles (ORVs), including all-terrain vehicles, represent a large injury risk to children. Several states allow unrestricted use by children, and previous state-level legislation has had variable effects on reducing pediatric injuries.

WHAT THIS STUDY ADDS: A comprehensive ORV law in Massachusetts including restrictions on age, engine size, and private land use has shown positive results in decreasing ORV-related injuries in children and could serve as a model for other state laws.

To cite: Flaherty MR, Raybould T, Kelleher CM, et al. Age Legislation and Off-Road Vehicle Injuries in Children. *Pediatrics*. 2017;140(4):e20171164

Off-road vehicles (ORVs) pose a significant injury risk to children. ORVs are motorized vehicles with 3 or more wheels designed for use over off-road terrain, including all-terrain vehicles (ATVs) and side by sides (SxSs), which include both utility terrain vehicles and recreational off-highway vehicles.^{1,2} ATVs are typically 4-wheeled ORVs with handlebars for steering and seats intended to be straddled by the driver. They have high centers of gravity and can achieve high speeds, making them unstable and unsafe for children.³ There have been more than 3000 ATV-related pediatric fatalities in the United States over the past 3 decades, with 12- to 15-year-olds accounting for more than half of these deaths.⁴ There were also ~360 000 emergency department (ED) visits for children younger than 15 years old for ATV-related injuries between 2001 and 2010.^{5,6} SxSs were involved in 335 fatalities and 506 injuries over a similar time frame, with drivers younger than 16 years old contributing to >50% of the incidents.^{1,2} The significant morbidity and mortality associated with the use of ORVs by children has led to medical societies, legislators, and health care providers advocating for federal safety standards and injury prevention legislation.^{3,5,7,8}

ORV injury prevention efforts began in the late 1980s when the Consumer Product Safety Commission (CPSC) and members of the ATV industry entered a 10-year consent decree that included the banning of 3-wheeled vehicles, a free nationwide training program offered to purchasers of new ATVs, and age recommendations for ATV use.^{4,9} The American Academy of Pediatrics (AAP) also became involved in 1987 with its first policy statement calling for several safety measures, including the prohibition of ATV use by children younger than 14 years old.¹⁰ This statement was followed by the introduction of a model bill for

legislators that further called for age restrictions up to 16 years of age.¹¹ The end of the 10-year CPSC decree in 1998 saw a dramatic increase in hospitalizations for and deaths from ATV-related pediatric injuries.³ By 2014, 44 states had responded to the rising injuries by enacting some form of legislation restricting the use of ORVs under certain age ranges or conditions.^{12,13} Many of these regulations had a questionable impact on pediatric injuries.^{8,14–18} Recent data from the CPSC demonstrated an overall slow decline in ATV-related fatalities since 2007 only to be superseded by another worrisome upward trend beginning in 2013.¹⁹

In October 2010, 4 years after the ORV-related fatality of an 8-year-old child, the Commonwealth of Massachusetts enacted legislation further restricting ORV use. An Act Regulating the Use of Off-Highway and Recreational Vehicles, or "Sean's Law," amended Massachusetts General Laws Chapter 90b Sections 21 to 35 and imposed the strictest statewide age restrictions for ORV riding in the United States. The new legislation applied to the operation of ATVs and "recreational utility vehicles," which are further described as SxSs and other nonmotorcycle ORVs. The law banned children 13 years old and younger from riding an ORV on public or private land unless "directly supervised by an adult on parent's land while in preparation for, or while participating in, a sanctioned race, rally or organized event which has been approved by a municipal permitting authority." The law went further by limiting children to vehicles with engine displacements <90 cm³. Children 14 to 17 years of age were mandated to take education and training classes and to be directly supervised by an adult while operating nonmotorcycle ORVs. The law continued helmet requirements, banned driving while under the

influence of alcohol, increased penalties for adults who allow their children to ride ORVs, and required vehicles to be registered with the state. It also called for the creation of an "Off-Road Vehicle Advisory Committee" to aid in the enforcement of the new regulations.

The Massachusetts law was the first to conform to nearly all the recommendations made by the AAP in its model bill and is based on recommendations made by professional societies, including the AAP, American College of Surgeons, the American Academy of Orthopedic Surgeons, and the American Pediatric Surgical Association.^{11,20–22} Because no similar laws have yet been analyzed, the objective of our study was to determine the overall impact of the 2010 Massachusetts ORV law by investigating population-based rates of ED visits and inpatient hospital discharges for ORV-related injuries in children <18 years of age before and after the legislation's implementation.

METHODS

The study was reviewed by the Massachusetts General Hospital Institutional Review Board and deemed exempt.

Study Period

The study period extended from January 2002 to December 2013, 9 years before and 3 years after the 2010 ORV law. The following 2 time periods were defined: the prelaw period (2002–2010) and the postlaw period (2011–2013). We included injuries from the time of the law's enactment in October 2010 through December 2010 in the prelaw cohort to allow for a 3-month implementation period.

Study Population

The study population included children younger than 18 years old who visited an ED or were admitted

TABLE 1 Characteristics of the Study Population and ORV-Related ED Visits Pre- and Postlaw

Age Group	0–9 y			10–13 y			14–17 y			25–34 y		
	Prelaw	Postlaw	<i>P</i>	Prelaw	Postlaw	<i>P</i>	Prelaw	Postlaw	<i>P</i>	Prelaw	Postlaw	<i>P</i>
Yearly population (mean)	767 914	747 103	—	336 969	319 337	—	350 512	335 736	—	843 331	894 882	—
Total ED visits	425	92	—	1001	159	—	1641	320	—	2290	777	—
ED visits per 100 000 population	6.15	4.1	.0004	33	16.6	<.001	52	31.8	<.001	30.2	28.9	.32
95% CI	5.59–6.76	3.35–5.04	—	31.0–35.1	14.2–19.4	—	49.6–54.6	28.5–35.4	—	29.0–31.4	27.0–35.4	—

CI, confidence interval; —, not applicable.

to a hospital in Massachusetts with the *International Classification of Diseases, Ninth Revision, Clinical Modification* external cause of injury codes (e-codes) specific to ORV-related injuries. E-codes E821.0, “non-traffic accident involving other off-road motor vehicle (MV); driver of MV other than motorcycle,” and E821.1, “non-traffic accident involving other off-road motor vehicle; passenger in MV other than motorcycle” were used. Data were provided by the Massachusetts Department of Public Health and derived from analysis of Massachusetts hospital discharge and ED discharge data from the Center for Health Information and Analysis.

Children were grouped into 4 age categories on the basis of changes specific to different age groups in the 2010 law. Group 1 (age 0–9 years) represented children who had been restricted from operating an ORV throughout the entire study period, both pre- and postlaw. Group 2 (age 10–13 years) represented children who, before 2010, could operate an ORV if supervised by a parent on private land but were banned from all ORVs postlaw unless participating in a sanctioned event. Group 3 (age 14–17 years) included children who could operate an ORV throughout the study period but were restricted to smaller engine sizes (14- to 16-year-olds) or required to take an ATV safety course (14- to 17-year-olds) postlaw. Group 4 (25- to 34-year-olds) was used as the comparison

cohort because this population would not have been directly affected by the ORV laws during the study period. This age group would also be old enough to not be experiencing any persistent effects of restrictions on younger persons. For inpatient hospital discharges, rates for children 0 to 17 years old were used because of a lower number of subjects and privacy restrictions on data use. The US Census Bureau database provided age-based population census data needed to derive population-based rates of ED and hospital discharges.

Primary Outcomes

The pre- and postlaw periods were compared for all 4 age groups. The primary outcomes were the rates of ED visits per population and the rates of inpatient hospital discharges per population.

Statistical Analysis

The rates of ED visits per 100 000 persons were derived and compared pre- and postlaw for all 4 age groups by using the total population of each age group (0–9, 10–13, 14–17, and 25–34 years old). The rates of inpatient hospital discharges per 100 000 persons were also derived for 2 age groups (0–17 and 25–34 years old) and compared pre- and postlaw. Poisson regression was used to compare the rates among age groups.

Segmented regression analysis was also used to evaluate the effectiveness of the law in children

<14 years old. Segmented regression analysis can detect whether an intervention effect is significantly greater than the secular trend.^{23,24} Yearly rates and percent change over time in the rate of the outcome during the prelaw period were compared with the percent change over time of the postlaw period. We used a Poisson regression model. The full segmented regression model included a prelaw intercept, a prelaw slope, a change in level after the law’s implementation, and a change in slope postlaw implementation. Backward stepwise regression methods were used to create a parsimonious segmented regression model by eliminating parameters with $P > .05$. A 2-sided $P \leq .05$ was considered statistically significant. Statistical analyses were performed in SAS software (Version 9.4; SAS Institute Inc, Cary, NC).

RESULTS

From 2002 to 2013, there were 3638 ED visits and 481 inpatient hospitalizations for ORV-related injuries in Massachusetts residents younger than 18 years old (Table 1).

Postlaw ED Visits

After the implementation of an updated ORV law in 2010, there was a 33% decline in the rates of ED visits for children ages 0–9 years ($P < .001$), a 50% decline in the rates of ED visits for 10- to 13-year-olds ($P < .001$), and a 39% decline in rates of ED visits

for 14- to 17-year-olds ($P < .001$) (Fig 1). There was no significant drop in the rates for 25- to 34-year-olds, with the rate of ED visits per population remaining stable at ~30.0 per 100 000 persons. Rates were overall the highest in 14- to 17-year-olds, with a prelaw rate of 52.0 per 100 000 persons that declined to 31.8 between 2011 and 2013.

Segmented regression analysis of population-based ED visits for 0- to 13-year-olds showed a significant 28.5% (95% confidence interval, 22.0%–34.6%) drop in the rate immediately after the law's implementation from 11.5 visits per 100 000 persons to 8.2 per 100 000 persons (Fig 2). The slope of the pre- and postlaw regression lines did not statistically differ. The model for 25- to 34-year-olds showed no statistical change in levels or slopes over time.

Postlaw Inpatient Hospitalizations

When comparing the pre- and postlaw periods, the rates for 0- to 17-year-olds declined by 41% ($P < .001$), whereas there was a 26% ($P = .04$) decline in the rates for 25- to 34-year-olds (Fig 1).

DISCUSSION

Since its implementation, the 2010 Massachusetts ORV legislation has contributed to a sustained decrease in the rates of ED visits and inpatient hospitalizations in children younger than 18 years old. In comparison, adults ages 25 to 34 years showed no change in their rates of ED visits during the study period and a less impressive drop in hospitalizations. The greatest decline in injuries was a 50% decrease in 10- to 13-year-olds, the cohort most affected by the age restriction of the new law (Table 1). Our results also demonstrate a significant 28% drop in the rate of ED visits in all children <14 years old in our state immediately after the law's implementation (Fig 2). Although there was a decline in injuries

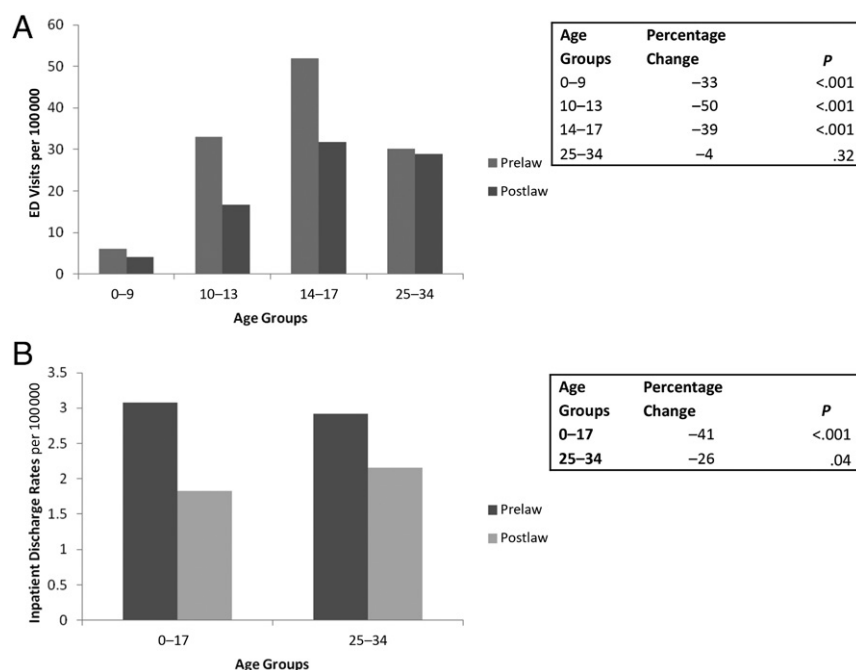


FIGURE 1 A, ED visits per population. B, Inpatient hospital discharges pre- and post-2010 ORV law in Massachusetts.

observed in the 14- to 17-year-old age group, this decrease was less robust, and these children continue to have the highest population-based injury rates in the state.

Before our findings, state-level ORV legislation had variable success in reducing pediatric injuries.^{5,14,16-18,25} Most laws have focused on education, training, helmet requirements, and prohibiting the riding of ORVs on public roads and highways.^{14,16,25-27} Few states have included meaningful age restrictions in their regulations. Because of this variability in ORV laws, the evaluation of their impact has been challenging. Furthermore, the lack of reliable data on ORV ridership, injury reporting, and enforcement have made it difficult to effectively comment on the outcomes of these laws. There is ongoing discussion about what restrictions to include in state laws to best protect young riders.^{6,18,26}

Debate on the impact of education and training on injury and fatality rates is longstanding. Most ATV riders report having had minimal

formal instruction in safe-riding practices.^{12,28,29} Previous studies have shown that safety education efforts are successful in increasing knowledge but are less effective at impacting riding behavior.²⁹⁻³¹ Helmkamp et al¹⁸ compared state-specific ATV fatality rates from 2000 to 2007 with 1990 to 1999 and found that statewide training requirements were not associated with decreased rates of ATV-related death rates. Therefore, the literature has suggested that an optimal state law needs to go beyond mandatory training requirements to be successful at combating pediatric ORV injuries and fatalities.

Of all the attempts to affect outcomes, helmet use has consistently been shown to have a significant effect on decreasing both the morbidity and mortality of ATV riders.^{12,25,32-34} Helmets have been shown to decrease head injuries by as much as 58% in ATV crashes as well as prevent facial and neck trauma.^{4,18,25} States with mandatory helmet-use requirements for ORV riders have

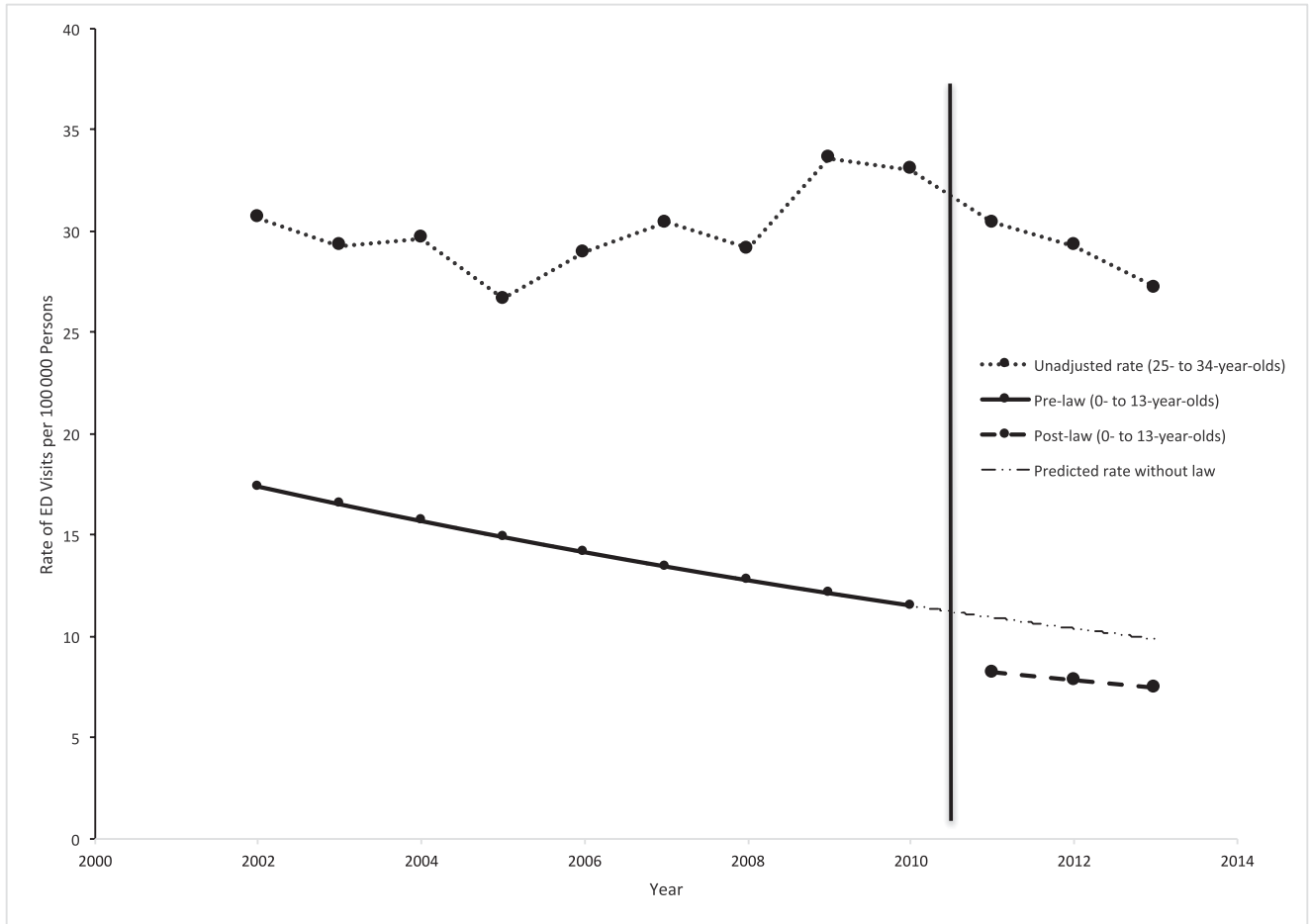


FIGURE 2

Segmented regression analysis of ED visits per population in 0- to 13-year-olds pre-law and postlaw from Poisson regression model versus unadjusted rates in 25- to 34-year-olds. The predicted rate without the law is shown as a dashed line extending from the prelaw line. The vertical line indicates the law's enactment.

also shown reduced rates of ORV-related deaths.¹⁸ Although lifesaving, routine helmet use by children occurs <50% of the time, recent literature suggests.³⁵ Additionally, although helmets are successful in the prevention of trauma to the head and neck, crush injuries from rollovers onto smaller children have not been impacted by helmet laws.^{36,37}

Age restrictions were missing from state ORV laws before the early 1990s. Since then, study conclusions have been mixed on whether they have had an impact on pediatric injury and fatality rates.^{7,14,16} Analyses of North Carolina and Pennsylvania laws demonstrated little to no

impact on the number of injuries postimplementation, although both states had age restrictions that were much younger than 14 years old.^{7,14,16} These studies also showed little change at a time when ATV injuries were markedly climbing in other states, suggesting some effect of legislation.⁷ Our results are the first to show substantial reductions in pediatric injuries after the passage of a state law with an age restriction that included all children up to age 14 years on both public and private land.³⁸

The previous Massachusetts law (passed in 1998) allowed children as young as 10 years old to operate ORVs on private land with adult

supervision. Given the increased injuries in this age group, as well as data showing more than half of pediatric injuries had occurred on private land, advocacy efforts in our state were successful in further regulating this vulnerable population.^{6,39,40} Figure 2 shows that the decline in injuries observed before 2010 was followed by an abrupt 28% drop in the population-based rate after the absolute age restriction (<14 years old). Specifically, we saw a 50% reduction in injuries in the 10- to 13-year-old age group, suggesting that these strict guidelines contributed to the effects seen. These results support the recommendations of professional societies that more stringent ORV

age restrictions may contribute to decreased morbidity.

Another important provision of the law that may have contributed to the favorable outcomes is the limitation of the size of a vehicle's engine to 90 cm³ for young riders. Not only does the engine size limitation decrease the maximum speed of the vehicle but it also substantially decreases the weight. This is significant in that orthopedic and crush injuries from rollovers on to smaller children are thought to contribute significantly to morbidity.^{35,36,41} Vehicles with larger engines that are designed for adults have been consistently shown to increase the risk for fatalities and injuries in children.^{42,43} After the implementation of the engine size restriction in Massachusetts, the rate of ED visits fell by 39% from 52 to 32 per 100 000 persons in the 14- to 17-year-old age group. At the same time, an additional provision (the mandatory training for youth) was broadened to include their parents. We postulate that the documented decrease in the injury rate is a combination of the strict, graded age restrictions of 14- to 16-year-olds, as well as an increased awareness of safe riding behaviors that are emphasized in the required training programs.

Our study has several limitations. First, it was conducted in a single state with lower exposure to ORVs than many other states.⁴⁴ A lack of accurate ORV-exposure data also makes rates difficult to determine. E-codes used in our analysis did not specify specific ORV subtypes. However, the Massachusetts law explicitly references all ORVs,

including SxSs and ATVs. The few other ORV vehicle types that might be included in the e-codes would likely have also shown similar decreases both pre- and postlaw and would be unlikely to adversely affect the analysis of the legislation's effects. Recently, we successfully advocated for new e-codes to better separate injuries related to 3- or 4-wheel ORVs from those related to motocross or dirt bikes; these will be available for use in fall 2017. Population-based data sets may also lose track of patients transported across state lines for care. Finally, it was difficult to study any of the individual components of the law in isolation or to control for enforcement of the law across the state, particularly on private land, to determine if any 1 of these variables had a greater effect than another.

CONCLUSIONS

ORV-related injuries continue to be a major public health problem, especially for those younger than 18 years old. Our study adds to the evidence in favor of legislation as an effective means of reducing pediatric ORV injuries and fatalities. Strong regulations should contain all the components outlined by the AAP model bill, including a minimum age requirement of 16 years. Our state's success, albeit with challenges, has shown promise in combating pediatric ORV-related injuries and could serve as an example in other states' efforts to strengthen their laws. Although our results are promising, it is our intention to continue to examine our state law's impact and sustainability as time

goes on. Future efforts will focus on increasing the minimum age requirements to 16 years as well as finding additional means to both analyze and strengthen enforcement.

ACKNOWLEDGMENTS

We thank the Massachusetts Department of Public Health for its help in data acquisition, especially Beth Hume for her help in data collection and retrieval. Thank you also to former Massachusetts State Senator and Chair of the Joint Committee on Transportation Steven Baddour for writing the ORV bill and advocating for the enactment of this legislation. We also thank former State Senate President Therese Murray, Speaker of the Massachusetts House Robert DeLeo, State Senator Viriato deMacedo, and Sheriff Peter Koutoujian for their efforts in getting Sean's Law passed. Finally, we acknowledge the Kearney family, whose selfless work after their personal loss helped prevent life-altering injuries to many children.

ABBREVIATIONS

AAP: American Academy of Pediatrics
ATV: all-terrain vehicle
CPSC: Consumer Product Safety Commission
e-code: external cause of injury code
ED: emergency department
ORV: off-road vehicle
SxS: side by side

REFERENCES

- U.S. Consumer Product Safety Commission. Notice of proposed rulemaking. 16 CFR part 1422. Safety standard for recreational off-highway vehicles (ROVs). *Fed Regist*. 2014;79:68964–69031
- Jennissen CA, Harland KK, Denning GM. Characteristics of side-by-side vehicle crashes and related injuries as determined using newspaper reports from nine U.S. States. *Safety*. 2016;2(2):10
- Bowman SM, Aitken ME. Still unsafe, still in use: ongoing epidemic of all-terrain vehicle injury hospitalizations among children. *J Trauma*. 2010;69(6):1344–1349
- Denning GM, Harland KK, Jennissen CA. Age-based risk factors for pediatric ATV-related fatalities. *Pediatrics*. 2014;134(6):1094–1102
- Shults RA, West BA, Rudd RA, Helmkamp JC. All-terrain vehicle-related nonfatal injuries among young riders in the United States, 2001-2010. *Pediatrics*. 2013;132(2):282–289
- Mazotas I, Toal M, Borrup K, et al. A prospective, multi-institutional study of pediatric all-terrain vehicle crashes. *J Trauma Acute Care Surg*. 2014;77(1):103–108; discussion 107–108
- McBride AS, Cline DM, Neiberg RH, Westmoreland KD. Pediatric all-terrain vehicle injuries: does legislation make a dent? *Pediatr Emerg Care*. 2011;27(2):97–101
- Upperman JS, Shultz B, Gaines BA, et al. All-terrain vehicle rules and regulations: impact on pediatric mortality. *J Pediatr Surg*. 2003;38(9):1284–1286
- U.S. Consumer Product Safety Commission. CPSC approves consent decrees for all-terrain vehicles. 1988. Available at: www.cpsc.gov/en/Newsroom/News-Releases/1988/CPSC-Approves-Consent-Decrees-for-All-Terrain-Vehicles/. Accessed October 11, 2016
- American Academy of Pediatrics Committee on Accident and Poison Prevention: all-terrain vehicles: two-, three-, and four-wheeled unlicensed motorized vehicles. *Pediatrics*. 1987;79(2):306–308
- All-terrain vehicle injury prevention: two-, three-, and four-wheeled unlicensed motor vehicles. *Pediatrics*. 2000;105(6):1352–1354
- Aitken ME, Graham CJ, Killingsworth JB, Mullins SH, Parnell DN, Dick RM. All-terrain vehicle injury in children: strategies for prevention. *Inj Prev*. 2004;10(5):303–307
- National Conference of State Legislators. All-terrain vehicle safety laws by state. Available at: http://www.ncsl.org/documents/transportation/ATV_TR-Jan2014.pdf. Accessed October 9, 2016
- Keenan HT, Bratton SL. All-terrain vehicle legislation for children: a comparison of a state with and a state without a helmet law. *Pediatrics*. 2004;113(4). Available at: www.pediatrics.org/cgi/content/full/113/4/e330
- Doud AN, Moro R, Wallace SG, et al. All-terrain vehicle injury in children and youth: examining current knowledge and future needs [published online ahead of print February 28, 2017]. *J Emerg Med*. doi:10.1016/j.jemermed.2016.12.035
- Beidler SK, Kromhout-Schiro S, Douillet CD, Riesenman PJ, Rich PB. North Carolina all-terrain vehicle (ATV) safety legislation: an assessment of the short-term impact on ATV-related morbidity and mortality. *N C Med J*. 2009;70(6):503–506
- Helmkamp JC. A comparison of state-specific all-terrain vehicle-related death rates, 1990-1999. *Am J Public Health*. 2001;91(11):1792–1795
- Helmkamp JC, Aitken ME, Graham J, Campbell CR. State-specific ATV-related fatality rates: an update in the new millennium. *Public Health Rep*. 2012;127(4):364–374
- Topping J. *2015 Annual Report of a TV-Related Deaths and Injuries*. Bethesda, MD: Consumer Product Safety Commission; 2017
- American College of Surgeons; Subcommittee on Injury Prevention and Control; Committee on Trauma. Statement on all-terrain vehicle injuries. *Bull Am Coll Surg*. 2009;94(2):37–38
- Burd R. American Pediatric Surgical Association Trauma Committee position statement on the use of all-terrain vehicles by children and youth. *J Pediatr Surg*. 2009;44(8):1638–1639
- American College of Orthopedic Surgeons. Position statement on all-terrain vehicles. 2015. Available at: https://www.aaos.org/uploadedFiles/PreProduction/About/Opinion_Statements/position/1101 - All Terrain Vehicles.pdf. Accessed December 15, 2016
- Lagarde M. How to do (or not to do) ... Assessing the impact of a policy change with routine longitudinal data. *Health Policy Plan*. 2012;27(1):76–83
- Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. *J Clin Pharm Ther*. 2002;27(4):299–309
- Bowman SM, Aitken ME, Helmkamp JC, Maham SA, Graham CJ. Impact of helmets on injuries to riders of all-terrain vehicles. *Inj Prev*. 2009;15(1):3–7
- Denning GM, Jennissen CA. All-terrain vehicle fatalities on paved roads, unpaved roads, and off-road: evidence for informed roadway safety warnings and legislation. *Traffic Inj Prev*. 2016;17(4):406–412
- Rodgers GB. The effectiveness of helmets in reducing all-terrain vehicle injuries and deaths. *Accid Anal Prev*. 1990;22(1):47–58
- Campbell BT, Kelliher KM, Borrup K, et al. All-terrain vehicle riding among youth: how do they fair? *J Pediatr Surg*. 2010;45(5):925–929
- Jennissen CA, Peck J, Wetjen K, Hoogerwerf P, Harland KK, Denning GM. The Safety Tips for ATV Riders (STARs) programme: short-term impact of a school-based educational intervention. *Inj Prev*. 2015;21(3):166–172
- Jepsen SD, Beaudreault AR. Ohio farm safety day camps: developing a successful statewide program through

- surveillance and evaluation. *J Agric Saf Health*. 2012;18(2):95–102
31. Novak JA, Hafner JW, Aldag JC, Getz MA. Evaluation of a standardized all-terrain vehicle safety education intervention for youth in rural Central Illinois. *J Prim Care Community Health*. 2013;4(1):8–13
 32. Denning G, Jennissen C, Harland K, Ellis D, Buresh C. All-terrain vehicles (ATVs) on the road: a serious traffic safety and public health concern. *Traffic Inj Prev*. 2013;14(1):78–85
 33. Merrigan TL, Wall PL, Smith HL, Janus TJ, Sidwell RA. The burden of unhelmeted and uninsured ATV drivers and passengers. *Traffic Inj Prev*. 2011;12(3):251–255
 34. McLean L, Russell K, McFaul S, Warda L, Tenenbein M, McGavock J. Age and the risk of All-Terrain Vehicle-related injuries in children and adolescents: a cross sectional study. *BMC Pediatr*. 2017;17(1):81
 35. Shults RA, West BA. ATV riding and helmet use among youth aged 12-17 years, USA, 2011: results from the YouthStyles survey. *Inj Prev*. 2015;21(1):10–14
 36. Linnaus ME, Raġar RL, Garvey EM, Fraser JD. Injuries and outcomes associated with recreational vehicle accidents in pediatric trauma. *J Pediatr Surg*. 2017;52(2):327–333
 37. Unni P, Morrow SEL, L Shultz B. Analysis of pediatric all-terrain vehicle trauma data in Middle Tennessee: implications for injury prevention. *J Trauma Acute Care Surg*. 2012;73(4suppl 3):S277–S280
 38. Meitrodt J. Massachusetts has nation's toughest ATV law. Available at: www.startribune.com/massachusetts-has-nation-s-toughest-atv-law/282723541/. Accessed December 15, 2015
 39. Denning GM, Harland KK, Ellis DG, Jennissen CA. More fatal all-terrain vehicle crashes occur on the roadway than off: increased risk-taking characterises roadway fatalities. *Inj Prev*. 2013;19(4):250–256
 40. Warda L, Klassen TP, Buchan N, Zierler A. All-terrain vehicle ownership, use, and self-reported safety behaviours in rural children. *Inj Prev*. 1998;4(1):44–49
 41. Balthrop PM, Nyland J, Roberts CS. Risk factors and musculoskeletal injuries associated with all-terrain vehicle accidents. *J Emerg Med*. 2009;36(2):121–131
 42. Butts CC, Rostas JW, Lee YL, et al. Larger ATV engine size correlates with an increased rate of traumatic brain injury. *Injury*. 2015;46(4):625–628
 43. Levenson M. All-terrain vehicle 2001 injury and exposure studies. 2003. Available at: www.cpsc.gov/PageFiles/102410/atvex2001.pdf. Accessed October 22, 2015
 44. Cordell HK, Betz CJ, Green GT, et al. Off-highway vehicle recreation in the United States and its regions and states. 2008. Available at: <https://www.fs.fed.us/recreation/programs/ohv/IrisRec1rpt.pdf>. Accessed October 22, 2016

Age Legislation and Off-Road Vehicle Injuries in Children

Michael R. Flaherty, Toby Raybould, Cassandra M. Kelleher, Raghu Seethala, Jarone Lee, Haytham M.A. Kaafarani and Peter T. Masiakos

Pediatrics 2017;140;

DOI: 10.1542/peds.2017-1164 originally published online September 11, 2017;

Updated Information & Services	including high resolution figures, can be found at: http://pediatrics.aappublications.org/content/140/4/e20171164
References	This article cites 37 articles, 11 of which you can access for free at: http://pediatrics.aappublications.org/content/140/4/e20171164.full#ref-list-1
Subspecialty Collections	This article, along with others on similar topics, appears in the following collection(s): Injury, Violence & Poison Prevention http://classic.pediatrics.aappublications.org/cgi/collection/injury_violence_-_poison_prevention_sub Public Health http://classic.pediatrics.aappublications.org/cgi/collection/public_health_sub
Permissions & Licensing	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: https://shop.aap.org/licensing-permissions/
Reprints	Information about ordering reprints can be found online: http://classic.pediatrics.aappublications.org/content/reprints

Pediatrics is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since . Pediatrics is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2017 by the American Academy of Pediatrics. All rights reserved. Print ISSN:

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™



PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Age Legislation and Off-Road Vehicle Injuries in Children

Michael R. Flaherty, Toby Raybould, Cassandra M. Kelleher, Raghu Seethala, Jarone Lee, Haytham M.A. Kaafarani and Peter T. Masiakos

Pediatrics 2017;140;

DOI: 10.1542/peds.2017-1164 originally published online September 11, 2017;

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://pediatrics.aappublications.org/content/140/4/e20171164>

Pediatrics is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since . Pediatrics is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2017 by the American Academy of Pediatrics. All rights reserved. Print ISSN:

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

