

Lawnmowers Versus Children: The Devastation Continues

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Abstract

Background Accidents with lawnmowers can cause mutilating injuries to children. Safety guidelines regarding the use of lawnmowers were promoted by professional organizations beginning in 2001. The Pennsylvania Trauma Systems Foundation maintains a database including all admissions to accredited Levels 1 to 4 trauma centers in the state. The annual rates of admission for children in our state and the severity of injuries subsequent to introduction of safety guidelines have not been reported,

to our knowledge. Ride-on lawnmowers have been associated with more severe injuries in children.

Questions/purposes We asked: (1) What was the incidence of hospital admissions for children with lawnmower-related injuries during 2002 to 2013 and did the incidence vary by age? (2) What was the severity of injuries and did the severity vary by age? (3) How often did these injuries result in amputation? (4) What types of lawnmowers were involved?

Methods This was a retrospective study using a statewide trauma registry. We queried the Pennsylvania Trauma Outcome Study database for children 0 to 17 years old admitted to trauma centers in Pennsylvania between January 2002 and January 2014 with injuries resulting from lawnmower-related accidents. All accredited Levels 1 to 4 trauma centers in the state are required to submit their data to the Pennsylvania Trauma Systems Foundation which maintains the Pennsylvania Trauma Outcome Study database. Demographic information, Injury Severity Scores, International Classification of Diseases procedure codes, and injury location codes were recorded. Type of lawnmower was determined from the narratives and was identified in 60% (119/199) of patients. Traumatic and surgical amputations performed during the index hospitalization were included in the analysis. Information on later surgeries was not available. Subjects were stratified by age: 0 to 6, 7 to 12, and 13 to 17 years old.

Results The incidence of lawnmower injuries in Pennsylvania was a median five of 100,000 children (range, 4–12/100,000) during the study period. The median age was 6 years (range, 1–17 years). The median Injury Severity Score was 4 (range, 1–75). Children 0 to 6 years old had higher median Injury Severity Scores (median, 8; range, 1–75) compared with those 13–17 years old (median, 4; range, 1–20; difference of the medians, 4; $p < 0.001$). A

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total of 53% of the patients (106/199) underwent at least one amputation. There were 83 amputations in or of the foot, 18 in the leg, 14 in the hand, and three in the arm. Ride-on lawnmowers accounted for 92% (110/119) of mowers identified by type.

Conclusions The incidence of serious injuries to children owing to lawnmower-related trauma did not change during the 12-year study period. If children younger than 6 years had not been near the lawnmower and those younger than 12 years had not been operating one, at least 69% of the accidents might have been prevented. We recommend annual publicity campaigns during spring to remind the public of the dangers of lawnmowers to children.

Level of Evidence Level IV, therapeutic study.

Introduction

The incidence of lawnmower injuries in the population younger than 20 years in the United States has been estimated to be 9400 per year [3, 22, 26]. Of those, 5.5% to 7.9% are admitted for treatment [3, 26]. A 66-cm (26-inch) lawnmower blade rotating at 3000 revolutions per minute has kinetic energy equal to 2848 J (2100 ft-lb) or the equivalent of dropping 9.5 kg (21 pounds) from a 30.5-m (100 feet) height [18]. As a consequence, children who require hospital admission for lawnmower-related trauma typically have sustained severe injuries [1, 7–9, 11–13, 15, 17, 20, 25–27]. These frequently include traumatic amputation, grossly contaminated wounds necessitating multiple operations, and extended lengths of stay. In the United States (US), lawnmowers account for 12% to 29% of all traumatic amputations in children [4, 6, 14]. The financial and social costs are considerable. Average hospital charges in 2003 for children with amputations of the leg were USD 120,275 [6]. Loder [14] estimated the annual financial burden to US society for pediatric prosthetic care resulting from lawnmower amputations ranged from USD 43.88 million to USD 75.42 million [14]. This does not include parental loss of time from work and psychologic comorbidity of patients [9, 21, 27].

In 2001 the American Academy of Pediatrics Committee on Injury and Poison Prevention implemented guidelines regarding the use of lawnmowers [5, 22]. Similar guidelines also were promoted by the American Academy of Orthopaedic Surgery [2]. Both recommend children younger than 6 years be kept indoors during lawnmower use, and the operation of push and riding mowers should be restricted to those 12 to 16 years or older, respectively. Recent clinical experience at a Level 1 pediatric trauma center led the authors to believe there had been no reduction in the incidence or severity of lawnmower-related trauma.

We therefore asked: (1) What was the incidence of hospital admissions for children with lawnmower-related injuries during 2002 to 2013? (2) What was the severity of injuries and did the severity vary by age? (3) What was the prevalence of amputations? (4) What types of lawnmowers were involved?

Patients and Methods

This was a retrospective study using a statewide trauma registry. The Pennsylvania Trauma Systems Foundation maintains the Pennsylvania Trauma Outcome Study database, to which all accredited Levels 1 to 4 trauma centers in Pennsylvania are required to submit their data [19]. The data for this study were collected from the 28 trauma centers reporting to the registry. Each is required to retain a trained registrar who collects data for every trauma admission. The dataset does not include followup information subsequent to discharge. The data are audited through an interrater reliability process at each reporting institution, required for accreditation.

Subjects who met inclusion criteria were stratified by age: 0 to 6 years old, 7 to 12 years old, and 13 to 17 years old. Stratification was based on published studies of lawnmower injuries in children which used the Consumer Products Safety Commission National Electronic Injury Surveillance System database and on national guidelines [2, 5, 22, 26]. Inclusion criteria were (1) age between 0 and 17 years old; (2) admission to a Pennsylvania Trauma Systems Foundation accredited hospital; and (3) injuries resulting from a lawnmower-related accident.

The data inquiry included International Classification of Diseases, 9th Revision (ICD-9) codes 919, 919.8, and 920 for patients admitted to pediatric and adult trauma centers in Pennsylvania from January 1, 2002, to December 31, 2013. ICD-9 code 920 is specific to lawnmower injuries; however, we noted other codes also were used for lawnmower injuries. Thus, the query included unspecified mechanism of injury codes (ICD-9 codes 919, 919.8). The mechanism of injury narratives then were examined and records containing the terms “lawn mower”, “lawnmower”, “mower”, and “lawn tractor” were included. All lawnmower types were included. Forty percent (80/199) of the narratives did not clearly specify the type of lawnmower involved in the accident.

Variables, Outcome Measures, Data Sources, and Bias

We recorded demographic information including age, sex, date of injury, and prehospital and hospital admission information. Injury Severity Scores (ISS), procedure codes,

and injury location codes were recorded. Only children admitted to an accredited trauma center in the state could be included, thus there is potential for selection bias. Although transfer bias is possible, it is not likely for entire records to be missing from the dataset used in this study. Codes used in the registry for amputations are general to the body part and do not distinguish by exact procedure type (eg, Syme or Boyd) and exact levels, therefore assessment bias is possible. The requirement for onsite registrars ensures high accuracy of the data in the Pennsylvania Trauma Outcome Study database.

Statistical Analysis

Statistical analysis was conducted using SAS® Version 9.4 (SAS Institute Inc, Cary, NC, USA). All variables were summarized with means, medians, and SDs or frequencies and percentages. The distribution of continuous outcome variables such as ISS and length of stay was assessed before any analysis using histograms, box plots, and the Kolmogorov-Smirnov test for normality. Because these outcome variables had skewed, nonnormal distributions, nonparametric tests were chosen that focused on medians rather than means. This included using a Kruskal-Wallis test with Wilcoxon Rank Sum tests for the pairwise group comparisons. The group comparisons were adjusted for multiple comparisons using the Bonferroni correction to maintain a groupwise Type I error rate of 0.05. For binary outcome variables such as admission to the intensive care unit, a logistic regression was applied that included odds ratios to determine the magnitude and direction of any significant associations. Statistical significance was always set at a probability less than 0.05.

Results

From January 1, 2002, to December 31, 2013, the incidence of children admitted to trauma centers with lawnmower injuries was a median five of 100,000 children per year (range, 4–12/100,000). The state population younger than 18 years by US Census Bureau estimate in 2002 was 2,863,452 and in 2014 was 2,702,674 [23, 24]. The annual rate of admission was median 15 per year (range, 12–35) and was relatively stable (Fig. 1). As expected in a state with a temperate climate, 90% (180/199) of incidences occurred between April and September. The median age of the patients was 6 years (range, 1–17 years). There was a bimodal distribution with peak incidences of admission for children at 4 years and 17 years old (Fig. 2). Patients 0 to 6 years, 7 to 12 years, and 13 to 17 years old accounted for 51% (102/199), 18% (36/199), and 31% (61/199) of those admitted, respectively. Eighty-one percent of the patients (161/199) were boys.

The overall median ISS was 4 (range, 1–75). Children 0 to 6 years old had higher median ISS (8; range, 1–75) than those 13 to 17 years old (4; range, 1–20; difference of the medians, 4; $p < 0.001$) (Table 1). The median length of stay was 4 days (range, 0–40 days). Children 0 to 6 years old had longer median lengths of stay (6 days; range, 0–40 days) compared with those 13 to 17 year old (median, 3 days; range, 1–13 days; difference of the medians, 3; $p < 0.001$) (Table 2). Twenty-four percent (47/199) of patients were admitted to an intensive care unit (Table 3). Children 0 to 6 years old were more likely than those 13 to 17 years old to be admitted to intensive care units (odds ratio [OR], 7; $p < 0.001$).

A total of 53% of patients (106/199) underwent at least one amputation during their hospital stay. There were 83 amputations in or of the foot, 18 in the leg, 14 in the hand,

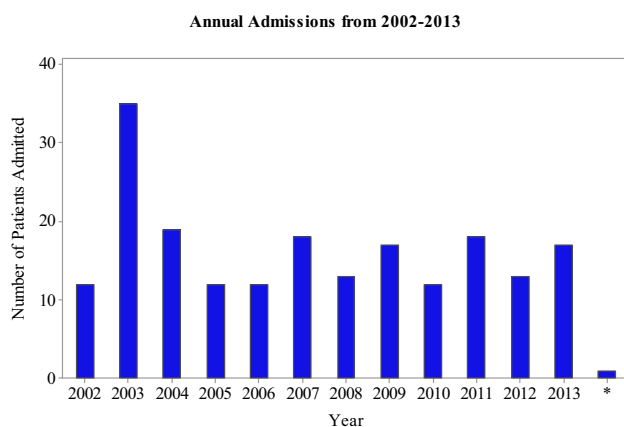


Fig. 1 The number of admissions of children with injuries associated with lawnmowers in Pennsylvania for 2002 through 2013 is shown in this bar graph. The year of injury was not clear for one record (*).

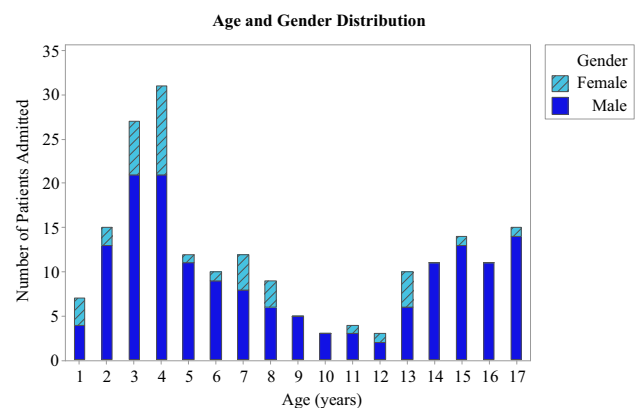


Fig. 2 The age and gender distributions of children admitted with lawnmower injuries in Pennsylvania for 2002 through 2013 are shown.

Table 1. Injury Severity Score for each age group of patients

0–6 years old Median (Q1, Q3)	7–12 years old Median (Q1, Q3)	13–17 years old Median (Q1, Q3)	Difference of medians	p Value*
8 (4, 9)	5 (4, 9)	NA	3	1.0
8 (4, 9)	NA	4 (4, 4)	4	< 0.001
NA	5 (4, 9)	4 (4, 4)	1	0.005

Q = quartile; NA = not applicable; *Wilcoxon Rank Sum test, all p values adjusted for three comparisons using the Bonferroni correction.

Table 2. Length of stay in days according to age group of patients

0–6 years old Median (Q1, Q3)	7–12 years old Median (Q1, Q3)	13–17 years old Median (Q1, Q3)	Difference of medians	p Value*
6 (3, 13)	5 (3, 9)	NA	1	1.000
6 (3, 13)	NA	3 (2, 4)	3	< 0.001
NA	5 (3, 9)	3 (2, 4)	2	0.002

Q = quartile; NA = not applicable; *Wilcoxon Rank Sum test, all p values adjusted for three comparisons using the Bonferroni correction.

Table 3. Frequency of admission to intensive care unit for each age group

Age of patient at the time of injury (n = 198)	Admitted to intensive care unit		Odds ratio (95% CI)*
	Yes	No	
0–6 years	34 (33)	68 (67)	7 (2–21)
7–12 years	4 (7)	56 (93)	4.67 (1–16)
13–17 years	9 (25)	27 (75)	Reference
Total	47 (24)	151 (76)	

*Odds ratios from a logistic regression, p value = 0.002.

and three in the arm. Among the reconstructive surgical procedures, there were a total of 42 skin grafts and 33 flaps performed. Fifty-four percent (107/199) of the patients sustained trauma to multiple anatomic locations. Lower extremity injuries were the most prevalent; 69% (137/199) of all injuries involved the foot (Table 4).

When compared with all other types, ride-on mowers resulted in a disproportionate number of injuries to multiple anatomic sites (29/89 versus 78/110; OR, 5; $p < 0.001$). Ride-on lawnmowers were associated with 92% (110/119) of the accidents for those in which type of lawnmower could be ascertained (Fig. 3).

Discussion

Among the traumatic wounds treated by surgeons who care for children, few are more dreadful than those associated with

lawnmowers. The young child admitted with lawnmower-related injuries typically has sustained high-energy trauma analogous to a blast injury [1, 7–9, 11–13, 15, 17, 20, 25, 27]. Although national estimates using US government data and institutional case series have been published [3, 26], the incidence and severity of trauma requiring surgical management remain unclear. By using a well-established statewide trauma registry we sought to determine (1) the contemporary incidence of pediatric lawnmower-associated injuries requiring hospital admission of children, (2) the severity of injuries, (3) the relationship of injury severity and age, and (4) the types of lawnmower involved. We found no change in the incidence of admission to the hospital in Pennsylvania for children 17 years or younger who had sustained lawnmower-related injuries during the study period.

The current study has limitations. First, although unlikely given the severity of the trauma and number of Levels 1 to 4 trauma centers included, it is possible the

Table 4. Anatomic sites of injury*

Age at time of injury (years)	Head	Shoulder	Arm	Forearm	Hand	Torso	Back	Hip/ pelvis	Thigh	Knee	Leg	Ankle	Foot
0–6	16 (8)	1 (0)	9 (4)	2 (1)	13 (6)	16 (8)	2 (1)	23 (12)	21 (11)	31 (16)	60 (30)	30 (15)	67 (34)
7–12	5 (2)	0 (0)	4 (2)	3 (1)	7 (3)	4 (2)	0 (0)	5 (2)	4 (2)	8 (4)	16 (8)	14 (7)	21 (11)
13–17	4 (2)	0 (0)	1 (0)	1 (0)	7 (3)	3 (1)	1 (0)	1 (0)	1 (0)	10 (5)	11 (5)	9 (4)	49 (25)
Total	25 (13)	1 (0)	14 (7)	6 (3)	27 (14)	23 (11)	3 (1)	29 (15)	26 (13)	49 (25)	87 (44)	53 (27)	137 (69)

*Presented as frequency (percent) in sites.

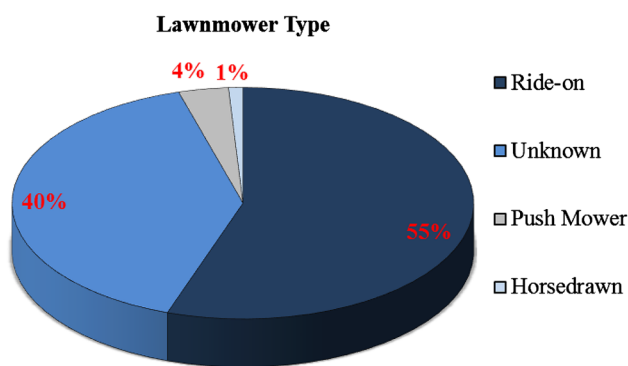


Fig. 3 The pie-chart representation shows distribution of the types of lawnmower involved in the accidents.

dataset does not include the entire pediatric trauma population and there could have been other hospitals that admitted children with lawnmower injuries. It is not possible to determine the number of children exposed to lawnmower use or the duration of exposure, therefore the incidence can be reported only per capita. However, our results in terms of demographics and severity of injury are similar to those of prior studies [1, 7–9, 11–13, 17, 25] and considering the state population, the incidence of 15 admissions per year is consistent with national estimates [3, 26]. We did not study the incidence before guideline introduction. Given the consistent number of yearly admissions, it seems reasonable to conclude there has been no change.

Our study represents one geographic area. The results may be most applicable to areas that have similar climate and population characteristics. Pennsylvania is in a temperate climate and has large rural regions in which family homes often are located on properties with large lawns. Other areas of the US with different climates such as southern states with longer growing seasons may have higher rates of injury.

The accuracy of coding and documentation in any registry potentially might be inconsistent. However, given the rigorous requirements for accreditation, including a trained on-site registrar, and a relatively large number of patients in the study, we believe the dataset to be accurate and reflective of the true incidence in our state. The Pennsylvania Trauma Outcome Study database does not include followup subsequent to the trauma admission. Readmissions for further surgeries or complications are not available, therefore the ultimate rate of amputation in children consequent to lawnmower injuries is likely to be higher than determined herein. Long-term function cannot be determined from this study.

To our knowledge, we report the largest series of children admitted to hospitals for treatment of lawnmower injuries. Vollman and Smith [26] estimated approximately 750 of the 9400 children injured by lawnmower accidents each year in the United States require hospital admission. Our study differs in that we used a statewide database to report actual hospital admissions and so distinguish children with severe injuries requiring surgery. Age distribution and frequencies of various types of injuries in the current study differ in some respects from studies using National Electronic Injury Surveillance Study data [3, 26]. Using that database to compare the interval 2004 to 2013 with 1990 to 2004, Bachier and Feliz [3] determined there was no change in the incidence of lawnmower injuries to children in the United States (10.6/100,000 children per year). They reported that 36% of injuries occurred in children younger than 12 years, and 79.5% of the children were boys. Similar to our report, a bimodal age distribution was found, peak incidences at ages 3 and 16 years. Median age at the time of injury was 13 years. In contrast to our study, frequent injuries to the upper extremity, face, and/or eye were recorded and the majority of patients were discharged from emergency departments. The results were similar to an earlier study based on the same database,

which found an annual incidence of 11.1 injuries per 100,000 children per year [26].

Severity of injury varies by age and can be very high in young children. In the current study children younger than 6 years sustained more severe injuries, reflected by higher ISS, required greater lengths of stay, and were more likely to be admitted to an intensive care unit. The median ISS was somewhat lower than reported in a prior study [11]. It is likely the differences are the result of differences in methodology and a larger variety of patients in our study. Length of stay varied by age, similar to prior studies [7–10, 12, 15, 17]. Fifty-three percent of the children underwent one or more amputations. This is similar to prior case series [7, 11, 15, 17, 25, 27]. A survey of the membership of Pediatric Orthopaedic Society of North America included 144 children [15]. In that study, the average age of the children was 7 years, 77% were boys, and amputations occurred in 67 children [15]. Amputations have been reported in as much as 82% of children admitted after accidents with riding lawnmowers [11]. Borne et al. [4] used data from the National Trauma Data Bank from 2007 to 2011 to study the incidence and characteristics of traumatic amputations in children younger than 18 years. Lawnmowers accounted for 12% of amputations, 75% of which involved the lower limb. The majority of lawnmower-related amputations occurred in younger children (57% in 0 to 5 years old). Power lawnmowers were more likely to be associated with severe lower extremity amputations in the youngest age group. The financial effect [6, 7, 9, 12, 16] and psychologic [9, 21] and social costs [7, 27] of traumatic amputation in children have been reported. In a study of 123 families of children who had undergone amputation, Weir et al. [27] reported extensive use of medical care and a substantial amount of time lost from school for limb loss-related problems. Parents experienced effects on their employment including changing jobs, leaving the workforce, altering hours, and missing days of work. Extended leaves of absence and work adjustments were common. Considerable time attending therapy and prosthetic appointments were required [27]. Rusch et al. [21] discussed psychologic consequences of traumatic amputation and disfiguring injuries to children. In a study of 57 children who sustained mutilating traumatic injuries to the face or upper or lower extremities, 44% of children continued to report symptoms of post-traumatic stress disorder, depression, or anxiety 1 year after injury [21].

Considering the published guidelines [5, 22], for the current series if children younger than 6 years had not been bystanders and those younger than 12 years had not been operating lawnmowers, at least 69% of the injuries might have been prevented. The preponderance of riding lawnmowers in the current study is the higher than that of prior

case series [7–11, 15, 17, 25, 27]. This may be in part a consequence of the large rural areas of the state and availability of relatively inexpensive machines. Safety mechanisms such as ‘no mow in reverse’ and automatic shutoffs may be overridden by the operator. The body and limbs of a small child can be entirely run over by a tractor-type riding lawnmower. As such, surgeons must be prepared to deal with major injuries when a riding lawnmower is reported to have been involved.

Gruel and Sullivan [10] concluded that “while we can legislate all we want and devise countless safety devices, the fact remains that the primary responsibility must be with parents and families”. Despite previous initiatives by specialty societies, the Consumer Product Safety Commission, and by manufacturers, lawnmower injuries in children remain a substantial burden to society. Perhaps specialty societies might consider annual promotions of springtime educational campaigns using internet and television, to promote lawnmower safety. They might also advocate for the use of environmentally friendly, low-maintenance groundcovers in place of turf grass.

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