

# Firework injuries before and after the Michigan Firework Safety Act

Melissa J. Shauver, MPH<sup>1</sup>

Kevin C. Chung, MD, MS<sup>2</sup>

1. At time of writing: Clinical Research Coordinator, Section of Plastic Surgery,  
Department of Surgery, University of Michigan Medical School  
Current: Clinical Research Manager, Department of Orthopaedic Surgery,  
Northwestern University Feinberg School of Medicine
2. Professor of Surgery; Section of Plastic Surgery; Department of Surgery; University of  
Michigan Medical School

Running head: Firework injuries in Michigan

Financial support: None

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the [Version of Record](#). Please cite this article as [doi: 10.1111/ACEM.14218](https://doi.org/10.1111/ACEM.14218)

This article is protected by copyright. All rights reserved

Author contributions: MJS: study concept and design, acquisition of the data, analysis and interpretation of the data, drafting of the manuscript; KCC: critical revision of the manuscript for important intellectual content

Conflict of interest disclosure: MJS reports no conflicts of interest. KCC reports no conflicts of interest.

Corresponding author:

Melissa J. Shauver, MPH

Department of Orthopaedic Surgery

Northwestern University Feinberg School of Medicine

359 E. Erie St; 13<sup>th</sup> floor

Chicago, IL 60611

Phone: 312-472-6024

E-mail: [melissa.shauver1@nm.org](mailto:melissa.shauver1@nm.org)

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30

MS. MELISSA J SHAUVER (Orcid ID : 0000-0001-5882-5986)

Article type : Research Letter

Approximately 10,000 firework-related injuries were treated in US emergency departments in 2019.<sup>1</sup> Although published reports use sources ranging from nationally representative datasets to single center censuses, patient demographic factors remain consistent. Patients are 70-90% male and approximately 50% are under the age of 20.<sup>1-4</sup> Injuries are most common to the hands, face, and eyes and are most often burns and lacerations. Although most injuries are minor, 11% of patients require admission or transfer to a higher-level facility and critical care admissions and deaths do occur.<sup>1,2</sup> Canner et al., using the Nationwide Emergency Department Sample, estimated \$8 million in annual charges for firework-related emergency department visits.<sup>2</sup>

In 2011, the Michigan State Legislature passed the Michigan Firework Safety Act (Act 256). Although entitled a Safety Act, the law allows the sale of consumer fireworks (i.e. fireworks that leave the ground), including bottle rockets, roman candles, and aerial spinners.<sup>5</sup> Previously, only on-ground fireworks (called low-impact fireworks) and novelty items (e.g. party poppers) were permitted. The possession of consumer fireworks prior to the Safety Act was illegal, although penalties were minor and were seldom enforced. Many Michigan residents simply went to neighboring states with more lenient firework laws to purchase consumer fireworks. The new law aimed to recover tax revenue lost to these nearby states and went into effect January 1, 2012. The aim of this project is to characterize firework injuries presenting to an adult and pediatric Level 1 trauma center from 2005-2018 to elucidate any temporal relationships between the sale of larger, more powerful fireworks and the number and severity of firework injuries.

The larger, more powerful fireworks now legal in Michigan cause disproportionately more severe and permanent injuries than other firework types, especially injuries to the hands

31 and eyes and traumatic brain injuries.<sup>3</sup> In a nationally representative sample, as more states  
32 allowed the sale of consumer fireworks the incidence of firework injuries increased modestly,  
33 but injuries became more severe. Injuries requiring hospital admission grew from 29% in 2006 to  
34 50% in 2012 with a corresponding length of stay increase from 3.1 days to 7.4 days.<sup>6</sup> State-level  
35 examinations have found similar results including escalated healthcare costs and insurance  
36 payouts for property damage.<sup>7,8</sup> In the years that the Michigan law has been in effect, there have  
37 been no published studies of firework injuries in the state. The law has been fiscally beneficial to  
38 the state; sellers' licenses and firework sales have generated more than \$18 million as of mid-  
39 2017.<sup>9</sup> However, this increased revenue may come at the cost of more or more severe injuries to  
40 Michigan residents.

41 We searched emergency department (ED) encounters from January 1, 2005 through  
42 December 31, 2018 to identify firework injuries using ICD-9/10 codes (E923.0 and W39,  
43 respectively) and our institution's Electronic Medical Record Search Engine (EMERSE), which  
44 permits Boolean searches of written portions of medical records, such as ED notes.<sup>10</sup> Exclusion  
45 criteria were: (1) injuries occurring outside of Michigan, (2) non-traumatic firework injury (e.g.  
46 ingestion of fireworks), (3) injuries at professional firework shows (regulations regarding use of  
47 professional-grade fireworks were not changed by the law) or (4) insufficient data available to  
48 complete data abstraction table. This study was approved by our Institutional Review Board.

49 Patient and injury factors were compared by date of injury (01/01/05-12/31/11 vs  
50 01/01/12-12/31/2018). Continuous variables (age and hospital length of stay) were checked for  
51 normality and compared using parametric or nonparametric t-tests as appropriate. Categorical  
52 variables (all others) were compared using chi square or Fisher exact test as appropriate.  
53 Significance was set at  $p < 0.05$ .

54 Our search yielded 619 unique patients. In 237 cases the word "firework" or "firecracker"  
55 was used in the ED note but there was no firework-related injury (e.g. patient reported visual  
56 distortions that looked like fireworks). Injuries in 109 cases were in the setting of watching  
57 fireworks, but were not caused by fireworks, including chest pain, falls, and assaults. In 17 cases,  
58 fireworks caused non- traumatic harm including asthma attacks and poisoning secondary to  
59 ingestion. Eleven patients were transferred from out of state. One patient was injured by flaming  
60 debris at a professional firework show. Two excluded patients presented to the ED for fractures

61 and also had recent firework burns for which medical treatment was neither required nor sought.  
62 Finally, one patient was seeking pain medication citing a past firework injury. 241 patient-  
63 encounters were included in this analysis. There were no duplicate patients. The majority of  
64 injuries (62%) occurred during a 2-week period before and after Independence Day. Another  
65 19% of injuries occurred in June or July outside of this 2-week period. Patients were  
66 disproportionately male (83%). (Table) Injured patients ranged in age from 2 months to 76 years,  
67 with a mean of 25 years; 40% of patients were under 18. The age groups with the highest  
68 proportion of injuries were patients under 5 years and those age 10-14 years.

69 The number of firework-related encounters from 2005-2011 was 81 compared to 160  
70 from 2012-2018. The number of all-cause ED encounters at our institution increased over this  
71 time period as well. The annual incidence rate of firework injuries presenting to the ED before  
72 the law change was 14.3/100,000; after the law change it was 21.0/100,000 ( $p=0.001$ ). Consumer  
73 fireworks caused the most injuries, whether or not their use was legal at that time. (Table 2) In  
74 both time periods, mortars (which include missile-type rockets, single tube devices with report,  
75 and reloadable shell devices) were the most common cause of injury followed by sparklers,  
76 bottle rockets/roman candles, and firecrackers, respectively. However, after the law change the  
77 proportion of injuries caused by mortars was significantly higher (59% vs 33%;  $p=0.02$ ). There  
78 was a corresponding significant increase in traumatic amputation post-law (7% vs 17%;  $p=0.04$ ).  
79 There were no differences in other injury types or injury location. At both times, over half of  
80 participants experienced burns, with lacerations and fractures also common.

81 Digits/hands, face, and eyes were injured most frequently. There were no differences in  
82 other injury characteristics based on time period. Both before and after the law, the patient was  
83 most often the firework user (74%). 70% of patients were transferred from another facility.  
84 Surgical treatment was required in 36% of cases. The patient was admitted 41% of the time and  
85 mean length of stay was 4.6 days (standard deviation: 6.6, range: 1-55). Because of transfers  
86 some patients did not receive follow-up treatment at our institution, but we were able to  
87 determine whether or not persistent disability was experience for the majority of patients. Most  
88 patients (71%) had no apparent lasting physical sequela from their injuries. Among the patients  
89 with long-term disability, 6 patients were treated with unilateral enucleation; an additional 5  
90 patients were left with unilateral light- or motion-perception only and 1 patient had bilateral  
91 light-perception only. Six patients had metacarpal level or proximal amputations. One patient

92 experienced a traumatic brain injury when he was hit in the face with a mortar resulting in  
93 persistent cognitive deficits. There were no fatalities in our cohort, although 1 patient was injured  
94 by an explosion of homemade fireworks that resulted in a fatality at the scene.

95 Our study shows that after the Michigan Firework Safety Act, the number of patients  
96 presenting to our institution's ED with firework-related injuries increased significantly.  
97 Additionally, a significantly higher proportion of injuries were caused by mortars and traumatic  
98 amputations increased significantly. Our data also shows that consumer fireworks injured  
99 patients even when they were illegal in Michigan, indicating that repeal of the law alone will not  
100 eliminate firework injuries. Our results are analogous to other analyses of state firework  
101 legislation. In 2002, Minnesota legalized the use of low-impact fireworks; previously only  
102 novelties had been permitted. Statewide emergency room records showed an over 100% increase  
103 in the number of firework-related injuries.<sup>8</sup> Likewise, in 2016, West Virginia legalized all  
104 consumer fireworks. Post-law the injury rate increased 39%.<sup>4</sup>

105 This study is subject to the limitations of all retrospective studies, including missed cases  
106 and incomplete medical record data. This study is also of a single center which may limit its  
107 generalizability. Nationally representative databases such as the National Trauma Databank and  
108 the Nationwide Emergency Department Sample stratify data only by region, not by state, so we  
109 could not use them for this examination of a single state law. However, our institution is both an  
110 adult and pediatric level 1 trauma center and thus receives cases from far outside its regular  
111 catchment area. We are likely, however, underestimating the number of less severe injuries that  
112 may be treated at community hospital emergency departments or urgent care centers. It is also  
113 possible that the increase in injuries was not related to the Michigan law, but was in response to  
114 other societal trends or factors. However, according to nationally representative samples there  
115 was no significant change in the rate of firework injuries during the study period.<sup>1,2</sup>

116 The debates of firework use in Michigan have taken place largely without evidence. Our  
117 analysis provides necessary data to inform policy discussions, namely that after loosening  
118 restrictions firework injuries increased at one level 1 trauma center and these injuries were more  
119 often caused by newly legal fireworks. Additional research, including a state-wide investigation  
120 and injury-prevention messaging, would further support discussion of the law's merits.

## 121 **References**

- 122 1. Marier A, Tu Y, Lee S. 2019 Fireworks Annual Report: Fireworks-Related Deaths,  
123 Emergency Department-Treated Injuries, and Enforcement Activities During 2019. United  
124 States Consumer Product Safety Commission; 2020.
- 125 2. Canner JK, Haider AH, Selvarajah S, Hui X, Wang H, Efron DT, et al. US emergency  
126 department visits for fireworks injuries, 2006-2010. *J Surg Res.* 2014;190(1):305–11.
- 127 3. Sandvall BK, Jacobson L, Miller EA, Dodge RE, Quistberg DA, Rowhani-Rahbar A, et al.  
128 Fireworks type, injury pattern, and permanent impairment following severe fireworks-  
129 related injuries. *Am J Emerg Med.* 2017;35(10):1469–73.
- 130 4. Rudisill TM, Preamble K, Pilkerton C. The liberalization of fireworks legislation and its  
131 effects on firework-related injuries in West Virginia. *BMC Public Health.* 2020;20:137-  
132 142.
- 133 5. State of Michigan Department of Licensing and Regulatory Affairs. Fireworks in Michigan  
134 [Internet]. 2019; Available from:  
135 [https://www.michigan.gov/documents/lara/fireworks\\_381040\\_7.pdf](https://www.michigan.gov/documents/lara/fireworks_381040_7.pdf)
- 136 6. Myers J, Lehna C. Effect of Fireworks Laws on Pediatric Fireworks-Related Burn Injuries.  
137 *J Burn Care Res.* 2017;38(1):e79–82.
- 138 7. Grant E, Fuller C, Birckmayer J, Marshall S, Peterson HD. State study of pyrotechnics-  
139 related injuries and property damage. *J Burn Care Rehabil.* 1998;19(3):265–7.
- 140 8. Roesler JS, Day H. Sparklers, smoke bombs, and snakes, oh my! Effect of legislation on  
141 fireworks-related injuries in Minnesota, 1999-2005. *Minn Med.* 2007;90(7):46–7.
- 142 9. Gray K. Changes to Michigan fireworks laws unlikely before “boom” season begins in  
143 earnest. *Detroit Free Press.* June 22, 2017.
- 144 10. Hanauer DA, Mei Q, Law J, Khanna R, Zheng K. Supporting information retrieval from  
145 electronic health records: A report of University of Michigan’s nine-year experience in  
146 developing and using the Electronic Medical Record Search Engine (EMERSE). *J Biomed*  
147 *Inform.* 2015;55:290–300.

Author Manuscript



Table. Demographic, firework, and injury factors before and after Michigan Firework Safety Act\*

	Before law change 01/01/05-12/31/11	After law change 01/01/12-12/31/18	p-value
Number of cases	81	160	
Number of cases per year			
mean (sd)	12 (2.9)	23 (4.3)	<b>0.0002</b>
median (range)	11 (9-18)	22 (18-30)	
Male, n(%)	67 (83%)	132 (83%)	0.95
Age			
mean (sd)	23 (15.7)	26 (16.6)	0.16
median (range)	20 (1-63)	25 (0-76)	
Race			
Black	11 (14%)	25 (16%)	0.93
White	64 (79%)	120 (75%)	
Other	6 (7%)	14 (9%)	
Unknown	0	1 (1%)	
Firework type <sup>a</sup>			
Consumer fireworks	43 (53%)	100 (66%)	0.62
Low Impact fireworks	17 (21%)	23 (14%)	
Novelties	1 (1%)	3 (2%)	
Illegal fireworks	6 (7%)	10 (6%)	
Homemade fireworks	8 (10%)	10 (6%)	
Unknown	6 (7%)	14 (6%)	
Specific firework <sup>b</sup>			
mortar	20 (33%)	74 (59%)	<b>0.02</b>
bottle rocket/roman candle	13 (21%)	15 (12%)	
firecracker	10 (16%)	11 (9%)	

sparkler	14 (23%)	19 (15%)	
other low-impact fireworks or novelties	4 (7%)	8 (6%)	
Was patient user of firework?			
no	16 (20%)	40 (25%)	0.36
yes	63 (78%)	116 (73%)	
unknown <sup>c</sup>	2 (2%)	4 (3%)	
Transfer			
no	26 (32%)	45 (28%)	0.54
yes	55 (68%)	115 (72%)	
Injury type <sup>d</sup>			
burn	45 (56%)	95 (59%)	0.57
laceration	14 (17%)	37 (23%)	0.29
traumatic amputation	6 (7%)	27 (17%)	<b>0.04</b>
foreign body	9 (11%)	11 (7%)	0.26
fracture	15 (19%)	19 (12%)	0.16
contusion	5 (6%)	15 (9%)	0.39
blast injury	11 (14%)	20 (13%)	0.81
corneal abrasion and/or burn	12 (15%)	21 (13%)	0.72
globe rupture	11 (14%)	11 (7%)	0.09
other	8 (10%)	23 (14%)	0.32
Injury area <sup>d</sup>			
eye	29 (36%)	51 (32%)	0.54
head/skull/brain	6 (7%)	13 (8%)	0.85
face	32 (40%)	47 (30%)	0.11
digit/hand	31 (38%)	77 (48%)	0.15
other upper extremity	12 (15%)	21 (13%)	0.72
trunk	7 (9%)	20 (13%)	0.37

lower extremity	4 (5%)	15 (9%)	0.23
Surgery required			
no	50 (62%)	105 (66%)	0.55
yes	31 (38%)	55 (34%)	
ED disposition			
discharged	45 (56%)	93 (58%)	0.95
admitted	34 (42%)	64 (40%)	
other	1 (1%)	2 (1%)	
Length of stay <sup>c</sup>			
mean (sd)	4 (5.1)	5 (7.3)	0.45
median (range)	2 (1-21)	3 (1-55)	

\*Law went into effect January 1, 2012.

a: Consumer fireworks: aerials, bottle/sky rockets, firecrackers, helicopters/spinners, missile-type rockets/mortars, roman candles, shell devices (single or reloadable). Low impact fireworks: smoke devices, sparklers, sparkling wheel devices. Novelties: party poppers, snakes, snappers. Federally-regulated illegal fireworks: cherry bombs, m80s; b: excluding illegal, homemade, and unknown fireworks; c: p-value calculated after removal of missing values; d: patients can have more than 1 type of injury and more than 1 injured area; e: among patients who were admitted