Nonpowder Firearm Injuries to Children Treated in Emergency Departments

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abstract

OBJECTIVES: To investigate nonpowder firearm injuries treated in US emergency departments among children <18 years old.

METHODS: National Electronic Injury Surveillance System data from 1990 through 2016 were analyzed.

RESULTS: An estimated 364 133 (95% confidence interval 314 540–413 727) children <18 years old were treated in US emergency departments for injuries related to nonpowder firearms from 1990 to 2016, averaging 13 486 children annually. From 1990 to 2016, the number and rate of nonpowder firearm injuries decreased by 47.8% ($P < .001$) and 54.5% ($P < .001$), respectively. Most injuries occurred among 6- to 12-year-olds (47.4%) and 13- to 17-year-olds (47.0%). Boys accounted for 87.1% of injured children, the most common diagnosis was foreign body (46.3%), and 7.1% of children were admitted. BB guns accounted for 80.8% of injuries, followed by pellet guns (15.5%), paintball guns (3.0%), and airsoft guns (0.6%). The rate of eye injuries increased by 30.3% during the study period. Eye injuries accounted for 14.8% of all injuries and the most common diagnoses were corneal abrasion (35.1%), hyphema (12.5%), globe rupture (10.4%), and foreign body (8.6%).

CONCLUSIONS: Although the number and rate of nonpowder firearm injuries declined during the study period, nonpowder firearms remain a frequent and important source of preventable and often serious injury to children. The severity and increasing rate of eye injuries related to nonpowder firearms is especially concerning. Increased prevention efforts are needed in the form of stricter and more consistent safety legislation at the state level, as well as child and parental education regarding proper supervision, firearm handling, and use of protective eyewear.

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WHAT'S KNOWN ON THIS SUBJECT: Although nonpowder firearms can cause serious pediatric injury, especially to the eyes, their regulation varies from state to state and no federal regulation exists. The American Academy of Pediatrics recommends use of protective eyewear when using nonpowder firearms.

WHAT THIS STUDY ADDS: On average, 13 486 pediatric nonpowder firearm injuries were treated in US emergency departments annually. Although the overall rate of these injuries declined by 54.5% from 1990 to 2016, nonpowder firearm eye injuries increased by 30.3%. Increased prevention efforts are needed.

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ARTICLE

SPIN MASTER 2118
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Nonpowder firearms have long been marketed to children and teenagers as toys or "starter" firearms and include paintball, airsoft, BB, and pellet guns. They use air pressure, carbon dioxide pressure, or spring-loaded action to propel metal or plastic projectiles of many shapes and sizes at varying velocities and are primarily used in target shooting, small animal hunting, and recreational combat simulation games (eg, paintball and airsoft). Although nonpowder firearms are recognized as an important source of pediatric injury, especially to the eyes,[1–4] their regulation varies from state to state, and no federal regulation exists.[5]

Previous studies of nonpowder firearm injuries have often focused on specific anatomic areas, such as the eyes, head, neck, or chest.[6–11] Others have been limited to reports of fatalities.[10,12,13] Most previous studies have had a small sample size or were conducted at a single center.[4,14–17] However, 3 previous studies analyzed a nationally representative sample from the National Electronic Injury Surveillance System (NEISS) database. One of those studies evaluated injuries from 1985 to 1999,[18] the second concentrated on pediatric eye injuries from 2002 to 2012,[6] and the third evaluated head and neck injuries from 2005 to 2014.[19] To our knowledge, our study is the first to comprehensively investigate all types of nonpowder firearm injuries among children and adolescents using a nationally representative sample.

METHODS

Data Source and Case Selection Criteria

This study retrospectively analyzed data regarding nonpowder firearm injuries among children <18 years of age treated in US emergency departments (EDs) from 1990 through 2016. Data were obtained from the NEISS, which monitors injuries associated with consumer products and sports and recreational activities treated in US EDs. The NEISS is maintained by the US Consumer Product Safety Commission (CPSC) and includes ~100 reporting hospitals that represent a stratified probability sample from the >5300 hospitals with at least 6 beds and a 24-hour ED in the United States and its territories.[20] Trained NEISS coders at participating hospitals extracted data from ED medical records, including patient demographics (including age and sex), consumer products or activities involved, injury diagnosis, affected body region, location where the injury occurred, disposition from the ED, and a brief narrative describing the circumstances of the injury incident.[20]

Nonpowder firearm injuries were identified by using NEISS product codes 1200 (for paintball [activity]: sports and recreational activity, not elsewhere classified), 1237 (gas, air, or spring-operated guns [including BB guns]), and 1936 (BBs or pellets [excluding shotgun pellets]). Each case narrative was reviewed and cases were excluded if they involved nonprojectile firearms, other projectile firearms, powder firearms, pellet or BB ingestions or foreign body insertions, injuries not directly related to use of the firearm, being hit or struck with the firearm, or if the mechanism of injury was unclear. The final data set consisted of 9739 actual cases included in analyses.

Study Variables

Children were categorized into 3 age groups: <6, 6 to 12, and 13 to 17 years old. Injury diagnosis was categorized as (1) contusion or abrasion, (2) foreign body, (3) fracture, (4) laceration, (5) puncture, and (6) other. Body region injured was grouped as (1) head and/or neck (including eyeball, face, head, neck, mouth, and ear), (2) trunk (including upper trunk, lower trunk, and pubic region), (3) upper extremity (including finger, hand, wrist, lower arm, elbow, upper arm, and shoulder), and (4) lower extremity (including toe, foot, ankle, lower leg, knee, and upper leg). Disposition from the ED was categorized as: (1) treated and released, (2) admitted (including hospitalized, transferred, held for observation for <24 hours, and treated and transferred for hospitalization), and (3) left against medical advice. Location of injury incident was grouped as (1) home (including home, mobile or manufactured home, apartment, and farm) and (2) other. Additional variables analyzed included sex and year.

The narrative from each case was reviewed and a variable describing the user of the nonpowder firearm was created, which included the categories of (1) self and (2) other person (including peer, adult, and other person of unspecified age). Using each case narrative, a variable describing the type of nonpowder firearm was created, which included the categories of (1) BB gun, (2) pellet gun, (3) airsoft gun, and (4) paintball gun.

Statistical Analysis

Data were analyzed by using SPSS version 20.0 (IBM SPSS Statistics, IBM Corporation) and SAS 9.4 (SAS Institute, Inc, Cary, NC). Complex survey procedures were used to calculate the national estimates using sample weights provided by the CPSC. All the estimates in the study are stable estimates unless stated otherwise. The CPSC considers an estimate to be unstable if the estimate is <1200, the sample size is <20 actual cases, or the coefficient of variation is >33%. Injury rates were calculated by using intercensal and postcensal population estimates obtained from the US Census Bureau.[21–23] Secular trends in the estimated annual number and rate of

TABLE 1 Characteristics of Nonpowder Firearm Injuries Treated in US EDs by Age Group (NEISS 1990–2016)

Characteristics	Age Group							
	<18 y Old		<6 y Old		6–12 y Old		13–17 y Old	
	n (%)[a]	95% CI	*n* (%)[a]	95% CI	*n* (%)[a]	95% CI	*n* (%)[a]	95% CI
Sex								
Male	317 220 (87.1)	273 565–360 875	14 019 (68.4)	11 216–16 823	151 650 (87.9)	128 191–175 109	151 550 (88.5)	130 181–172 920
Female	46 831 (12.9)	39 892–53 770	6473 (31.6)	4869–8077	20 762 (12.0)	17 218–24 305	19 597 (11.4)	16 385–22 809
Unknown	83[b]	0–173	0	0	61[b]	0–147	21[b]	0–54
Body region injured								
Head and/or neck	143 046 (39.3)	122 224–163 869	10 435 (50.9)	8335–12 534	67 094 (39.0)	55 978–78 210	65 518 (38.3)	55 612–75 424
Upper extremity	111 784 (30.7)	96 207–127 361	5350 (26.1)	4002–6698	49 311 (28.6)	41 433–57 190	57 123 (33.4)	48 656–65 590
Trunk	33 990 (9.3)	28 423–39 557	2734 (13.3)	1867–3600	18 183 (10.6)	14 721–21 646	13 073 (7.6)	10 518–15 628
Lower extremity	74 770 (20.6)	63 503–86 037	1968 (9.6)	1156–2780	37 588 (21.8)	30 862–44 313	35 214 (20.6)	29 843–40 586
Other	229 (<0.1)[b]	13–444	6 (<0.1)[b]	0–17	12 (<0.1)[b]	0–28	211 (0.1)[b]	0–425
Not specified	315[b]	68–562	0	0	286[b]	41–530	29[b]	0–66
Diagnosis								
Contusion or abrasion	49 006 (13.5)	39 529–58 482	3660 (17.9)	2432–4888	23 691 (13.8)	18 903–28 479	21 655 (12.7)	16 913–26 397
Foreign body	168 276 (46.3)	142 874–193 679	7231 (35.3)	5502–8960	77 673 (45.1)	64 552–90 795	83 372 (48.8)	70 112–96 632
Fracture	6755 (1.9)	5023–8488	265 (1.3)[b]	40–489	3202 (1.9)	2118–4286	3288 (1.9)	2232–4345
Laceration	15 464 (4.3)	12 721–18 207	1338 (6.5)	663–2013	7044 (4.1)	5464–8623	7082 (4.1)	5481–8683
Puncture	81 182 (22.3)	67 376–94 987	5733 (28.0)	4323–7143	40 081 (23.3)	31 746–48 415	35 368 (20.7)	29 280–41 456
Other	42 882 (11.8)	35 187–50 578	2266 (11.1)	1409–3122	20 571 (11.9)	16 390–24 751	20 046 (11.7)	16 254–23 838
Not specified	568[b]	105–1031	0	0	212[b]	0–471	356[b]	0–746
Disposition from ED								
Treated and released	336 280 (92.4)	290 269–382 290	17 924 (87.5)	14 409–21 439	158 362 (91.9)	134 408–182 317	159 993 (93.5)	137 352–182 634
Admitted	26 002 (7.1)	21 182–30 821	2307 (11.3)	1508–3106	13 397 (7.8)	10 280–16 513	10 298 (6.0)	8161–12 434
Left against medical advice	1638 (0.5)	780–2496	261 (1.3)[b]	0–638	588 (0.3)[b]	197–979	789 (0.5)[b]	259–1319
Not specified	214[b]	20–408	0	0	126[b]	0–253	88[b]	0–240
Location of incident								
Home	195 584 (89.4)	161 180–229 988	13 955 (96.9)	11 008–16 902	97 262 (91.5)	79 141–115 383	84 367 (86.0)	68 307–100 428
Other	23 256 (10.6)	18 003–28 510	444 (3.1)[b]	82–805	9077 (8.5)	6833–11 321	13 736 (14.0)	10 194–17 279
Not specified	145 293	120 867–169 720	6094	4432–7755	66 135	53 314–78 956	73 065	61 129–85 000
Intent								
Unintentional	188 129 (99.0)	159 860–216 397	10 332 (99.8)	8125–12 539	85 988 (98.6)	72 132–99 843	91 809 (99.2)	77 063–106 555
Intentional	1960 (1.0)	1130–2791	21 (0.2)[b]	0–52	1221 (1.4)	651–1790	719 (0.8)[b]	292–1146
Not specified	174 045	148 276–199 813	10 139	7387–12 892	85 265	70 618–99 912	78 640	67 353–89 926
Type of firearm								
BB gun	240 522 (80.8)	207 158–273 885	14 566 (86.5)	11 635–17 497	118 084 (83.6)	100 011–136 156	107 872 (77.3)	92 222–123 522
Pellet gun	46 208 (15.5)	38 952–53 463	1867 (11.1)	1162–2571	19 391 (13.7)	15 444–23 338	24 950 (17.9)	20 724–29 176
Airsoft gun	1915 (0.6)	654–3176	115 (0.7)[b]	0–267	752 (0.5)[b]	228–1275	1048 (0.8)[b]	220–1876
Paintball gun	8958 (3.0)	6244–11 672	297 (1.8)[b]	0–608	3034 (2.1)	1916–4153	5627 (4.0)	3748–7505
Not specified	66 531	55 597–77 466	3647	2570–4724	31 213	25 254–37 172	31 671	26 319–37 023

3

TABLE 1 Continued

Characteristics	Age Group							
	<18 y Old		<6 y Old		6–12 y Old		13–17 y Old	
	n (%)[a]	95% CI	*n* (%)[a]	95% CI	*n* (%)[a]	95% CI	*n* (%)[a]	95% CI
User of firearm								
Self	103 416 (52.8)	86 564–120 267	3819 (33.2)	2414–5224	43 934 (47.5)	36 210–51 658	55 663 (60.6)	45 956–65 370
Other	92 466 (47.2)	78 793–106 138	7688 (66.8)	5902–9473	48 515 (52.5)	40 150–56 880	36 263 (39.4)	30 424–42 102
Not specified	168 253	144 151–192 355	8986	6688–11 283	80 024	66 848–93 201	79 242	68 025–90 460
Total	364 133 (100.0)	314 540–413 727	20 492 (5.6)	16 711–24 273	172 473 (47.4)	146 332–198 615	171 168 (47.0)	147 393–194 943

[a] Column percentages may not sum to 100.0% because of rounding error.

[b] Potentially unstable estimate because the sample is <20, estimate is <1200, or coefficient of variation is >33%.

injuries were assessed using simple or piecewise linear regression as appropriate. The estimated slope from regression models was reported along with the associated *P* value. Other statistical analyses included calculation of odds ratios (ORs) with 95% confidence intervals (CIs) using complex survey procedures. Statistical significance was set at 0.05. This study was determined to be exempt by the institutional review board of the authors' institution.

RESULTS

General Characteristics

An estimated 364 133 (95% CI: 314 540–413 727) children <18 years of age with nonpowder firearm injuries were treated in US EDs from 1990 through 2016, averaging 13 486 children annually or 18.8 injuries per 100 000 US children <18 years old. Most injuries occurred among children 6 to 12 years old (47.4%) and 13 to 17 years old (47.0%), with only 5.6% of injuries being observed among children <6 years of age. The average age was 11.8 years (SD: 3.5; interquartile range: 10–14 years). Boys accounted for 87.1% of injuries, and among cases with a documented location of injury, most (89.4%) occurred at home (Table 1).

Body Region Injured

The head and neck were the most commonly injured body region (39.3%), followed by upper extremity (30.7%) and lower extremity (20.6%). BB guns (35.4%), paintball guns (80.6%), and airsoft guns (100.0%) commonly were associated with injuries to the head and neck, whereas injuries from pellet guns (33.7%) were often to the upper extremity (Table 2). Patients <6 years old more commonly sustained an injury to the head and neck (OR: 1.65; 95% CI: 1.31–2.07) than older patients, and patients 13 to 17 years old were treated more often (OR: 1.26; 95% CI: 1.12–1.43) for an upper extremity injury than younger patients. Among injuries to the head and neck, 36.1% were diagnosed as foreign body, 23.6% were diagnosed as a contusion or abrasion, and 11.9% resulted in hospital admission. Among the head and neck injuries, 37.7% (*n* = 53 994; 95% CI: 43 602–64 386) were related to the eye. Eye injuries accounted for 14.8% of all nonpowder firearm injuries.

Diagnosis

The most common diagnosis was foreign body (46.3%), followed by puncture (22.3%) and contusion or abrasion (13.5%); this pattern was consistent across all age groups. More than two-thirds (68.9%) of contusions and abrasions were to the head and neck, whereas foreign body injuries were commonly to an upper extremity (37.2%), followed by head and neck (30.7%). Corneal abrasion (35.1%) was the most common diagnosis among eye injuries. Patients 13 to 17 years of age had higher odds (OR: 1.74; 95% CI: 1.36–2.22) of being diagnosed with a foreign body than patients <13 years old. BB guns (50.6%) and pellet guns (41.7%) commonly resulted in foreign body-related injuries, whereas paintball guns were frequently associated a contusion or abrasion (50.2%; Table 2). Fractures were most commonly associated with hospital admission (9.7%), followed by punctures (6.7%) and lacerations (5.9%).

Corneal abrasion (35.1%), hyphema (12.5%), foreign body (10.9%), and globe rupture (10.4%) were the most common diagnoses among the eye injuries (Table 3). The proportion of injured children who required hospital admission varied by type of eye injury and was highest for globe rupture (62.0%), followed by foreign body (41.5%) and hyphema (27.5%). Globe rupture had higher odds of hospital admission than other types

TABLE 2 Characteristics of Nonpowder Firearm Injuries Treated in US EDs by Type of Firearm (NEISS 1990–2016)

Characteristics	Type of Firearm							
	BB Gun		Pellet Gun		Airsoft Gun		Paintball Gun	
	n (%)[a]	95% CI	*n* (%)[a]	95% CI	*n* (%)[a]	95% CI	*n* (%)[a]	95% CI
Sex								
Male	208 482 (86.7)	179 468–237 497	40 304 (87.2)	33 735–46 873	1766 (92.2)	629–2904	8122 (90.7)	5627–10 617
Female	32 018 (13.3)	26 806–37 231	5904 (12.8)	4386–7421	149 (7.8)[b]	0–341	836 (9.3)[b]	410–1261
Unknown	21[b]	0–54	—	—	—		—	—
Age group, y								
<6	14 566 (6.1)	11 635–17 497	1867 (4.0)	1162–2571	115 (6.0)[b]	0–267	297 (3.3)[b]	0–608
6–12	118 084 (49.1)	100 011–136 156	19 391 (42.0)	15 444–23 338	752 (39.3)[b]	228–1275	3034 (33.9)	1916–4153
13–17	107 872 (44.8)	92 222–123 522	24 950 (54.0)	20 724–29 176	1048 (54.7)[b]	220–1876	5627 (62.8)	3748–7505
Body region injured								
Head and/or neck	85 178 (35.4)	72 841–97 515	13 775 (29.9)	11 012–16 538	1915 (100.0)	654–3176	7224 (80.6)	4998–9451
Upper extremity	78 551 (32.7)	67 028–90 075	15 531 (33.7)	12 833–18 229	—	—	859 (9.6)[b]	351–1368
Trunk	23 201 (9.7)	18 984–27 418	5742 (12.5)	4254–7229	—	—	430 (4.8)[b]	127–732
Lower extremity	53 226 (22.1)	45 319–61 133	11 052 (24.0)	8577–13 527	—	—	445 (5.0)[b]	84–805
Other	194 (0.1)[b]	0–405	6 (0.1)[b]	0–17	—	—	—	—
Not specified	171[b]	0–352	103[b]	0–264	—	—	—	—
Diagnosis								
Contusion or abrasion	25 030 (10.4)	19 802–30 258	5203 (11.3)	3805–6601	941 (49.1)[b]	343–1539	4500 (50.2)	2923–6078
Foreign body	121 500 (50.6)	102 753–140 247	19 272 (41.7)	15 200–23 344	122 (6.4)[b]	0–286	197 (2.2)[b]	0–428
Fracture	4514 (1.9)	3238–5791	1292 (2.8)	711–1873	—	—	122 (1.4)[b]	0–276
Laceration	9441 (3.9)	7373–11 509	3079 (6.7)	2230–3927	11 (0.6)[b]	0–34	653 (7.3)[b]	259–1046
Puncture	57 848 (24.1)	47 882–67 814	11 784 (25.5)	9197–14 370	70 (3.7)[b]	0–199	92 (1.0)[b]	0–233
Other	21 713 (9.0)	17 345–26 081	5573 (12.1)	4211–6934	770 (40.2)[b]	183–1358	3394 (37.9)	2162–4627
Not specified	475[b]	75–876	6[b]	0–18	—	—	—	—
Disposition from ED								
Treated and released	223 915 (93.2)	192 712–255 118	42 131 (91.2)	35 408–48 855	1766 (92.2)	583–2948	7835 (87.5)	5280–10 390
Admitted	15 518 (6.5)	12 438–18 599	3854 (8.3)	2779–4928	134 (7.0)[b]	0–292	1091 (12.2)[b]	542–1641
Left against medical advice	880 (0.4)[b]	351–1409	223 (0.5)[b]	0–464	15 (0.8)[b]	0–46	32 (0.4)[b]	0–75
Not specified	208[b]	16–400	—	—	—	—	—	—
Location of incident								
Home	135 851 (91.3)	111 343–160 359	27 058 (93.3)	21 606–32 510	1087 (91.2)[b]	225–1949	2717 (54.3)	1662–3772
Other	12 992 (8.7)	9992–15 991	1933 (6.7)	1306–2559	105 (8.8)[b]	0–253	2291 (45.7)	1253–3330
Not specified	91 679	75 812–107 546	17 217	13 652–20 783	723[b]	253–1193	3950	2252–5648
Total[c]	240 522 (100.0)	207 158–273 885	46 208 (100.0)	38 952–53 463	1915 (100.0)	654–3176	8958 (100.0)	6244–11 672

—, not applicable.

[a] Column percentages may not sum to 100.0% because of rounding error.

[b] Potentially unstable estimate because the sample is <20, estimate is <1200, or coefficient of variation is >33%.

[c] Total may not add to all estimated cases in the study because of missing values.

of eye injury (OR: 7.68; 95% CI: 5.02–11.74), and foreign body also had greater odds of admission than other eye injury diagnoses (OR: 2.88; 95% CI: 1.82–4.56).

Disposition From the ED

Hospital admission occurred for 7.1% of patients with a nonpowder firearm injury. There were no fatalities. Among admitted patients, 47.5% were 6 to 12 years old, 65.9% had an injury to the head and neck, and 36.9% were diagnosed with a foreign body. Paintball gun–related injuries had the highest proportion of hospital admission (12.2%), followed by pellet guns (8.3%) and airsoft guns (7.0%). Compared with 13- to 17-year-old patients, patients <6 years old (OR: 1.98; 95% CI: 1.31–2.98) and patients 6 to 12 years old (OR: 1.31; 95% CI: 1.03–1.67) had higher odds of admission. Injuries to the head and neck (OR: 8.24; 95% CI: 5.32–12.75) and upper extremity (OR: 9.01; 95% CI: 5.67–14.32) had greater odds of admission compared with injuries to the lower extremity.

Injury Intent, Firearm User, and Type of Firearm

Injury intent was documented in 52.2% of cases, of which 1.0% (assaults and self-injury) were intentional. Among cases for which the user of the firearm could be determined (53.8%), the majority (52.8%) of injuries were self-inflicted. Self-inflicted injuries were more common among 13- to 17-year-olds (60.6%), while injuries involving others predominated among patients <6 years old (66.8%). Among cases in which the type of firearm could be determined, BB guns accounted for 80.8% of injuries, followed by pellet guns (15.5%), paintball guns (3.0%), and airsoft guns (0.6%).

Trends

From 1990 to 2016, the annual number and rate (per 100 000 children <18 years old) of

TABLE 3 Frequency and Percentage of Specific Diagnoses Among Nonpowder Firearm Eye Injuries Treated in US EDs (NEISS 1990–2016)

Eye Injury Diagnosis	Estimated Frequency (95% CI)	%[a]
Corneal abrasion	18 960 (14 309–23 610)	35.1
Hyphema	6763 (5007–8519)	12.5
Foreign body	5922 (4192–7652)	10.9
Globe rupture	5640 (4320–6959)	10.4
Contusion	3675 (2386–4964)	6.8
Traumatic iritis or uveitis	1804 (954–2655)	3.3
Subconjunctival hemorrhage	1667 (940–2393)	3.1
Retinal injury[b]	380 (99–661)	0.7
Iridodialysis[b]	359 (39–679)	0.7
Vitreous hemorrhage[b]	269 (23–514)	0.5
Other or unspecified	8555 (5078–12 066)	18.2
Total	53 994 (43 602–64 386)	100.0

[a] Percentages may not sum to 100.0% because of rounding error.
[b] Potentially unstable estimate because the sample is <20, estimate is <1200, or coefficient of variation is >33%.

nonpowder firearm injuries decreased significantly by 47.8% (slope = −415.32; $P < .001$) and 54.5% (slope = −0.67; $P < .001$), respectively (Fig 1). The decreasing trend was consistent across all age groups and both sexes, with the greatest decrease in injury rate observed among 13- to 17-year-olds (−59.7%; slope = −1.09; $P < .001$) and boys (−56.7%; slope = −1.14; $P < .001$). BB guns showed the greatest decrease in injury rate (−60.9%; slope = −0.5; $P < .001$), followed by pellet guns (−14.3%; slope = −0.05; $P < .001$; Fig 2). Contrary to this overall trend, the annual number and rate (per 100 000 children <18 years old) of eye injuries associated with nonpowder firearms increased significantly from 1990 to 2016 by 49.5% (slope = 54.19; $P = .003$) and 30.3% (slope = 0.46; $P = .006$), respectively, with a peak in 2006 (Fig 3).

DISCUSSION

There were an estimated 364 133 children with nonpowder firearm injuries treated in US EDs from 1990 through 2016, averaging 13 486 annually. Consistent with previous studies, the head and neck were the most commonly injured body region, with frequent involvement of the eyes.[4,6,19,24] The overall number and rate of nonpowder firearm injuries decreased significantly during the study period by 47.8% and 54.5%, respectively. However, eye injuries associated with nonpowder firearms demonstrated the opposite trend, with the number and rate increasing significantly by 49.5% and 30.3%, respectively. This is in agreement with previous reports.[6,24]

Nonpowder firearms should be regarded as potentially lethal weapons. Most fire projectiles in excess of the minimum velocity to penetrate human skin, which is ~70 m per second (230 ft per second) with an energy/area of presentation of ~2.1 m-kg per cm,[3,25] and many achieve a muzzle velocity similar to a handgun.[26,27] Fatal injuries from nonpowder firearms have been reported and most often are associated with penetrating wounds to the head, neck, or chest.[10,12,13] Although there were no deaths reported in our study, the NEISS does not adequately capture fatalities because deaths are not consistently transported to the ED and those that occur after admission to the hospital are missed when only the ED medical record is reviewed.

There were an estimated 53 994 eye injuries in our study, accounting for 14.8% of all nonpowder firearm injuries. These injuries were often serious with 22.2% requiring admission to the hospital. The rate of eye injuries increased by 30.3% during the study period. These findings agree with previous studies, which emphasize that eye injuries are commonly reported in association with nonpowder firearms and can result in serious adverse outcomes, including partial or complete vision loss.[4,6,7,11] Indeed, nonpowder firearms account for most pediatric eye injuries that are admitted to the hospital.[6] Educational efforts to prevent nonpowder firearm eye

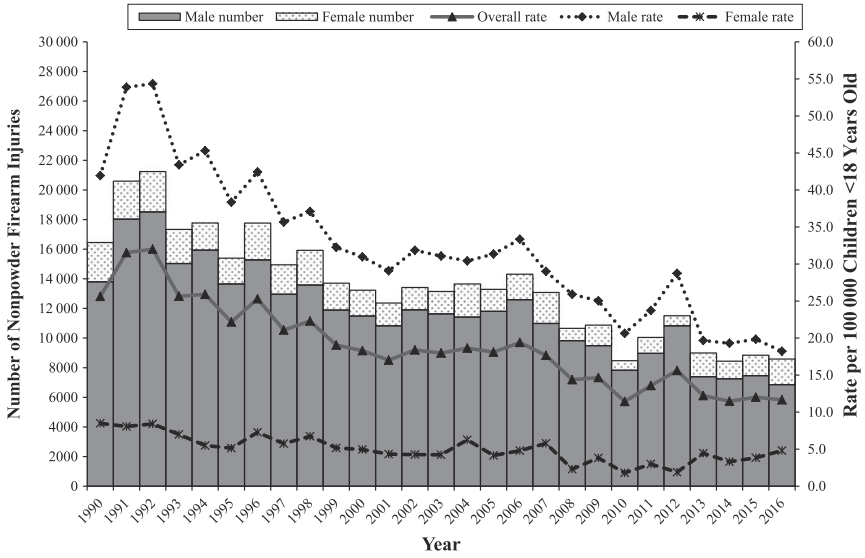

FIGURE 1
Estimated annual number and rate of nonpowder firearm injuries by sex (NEISS 1990–2016).

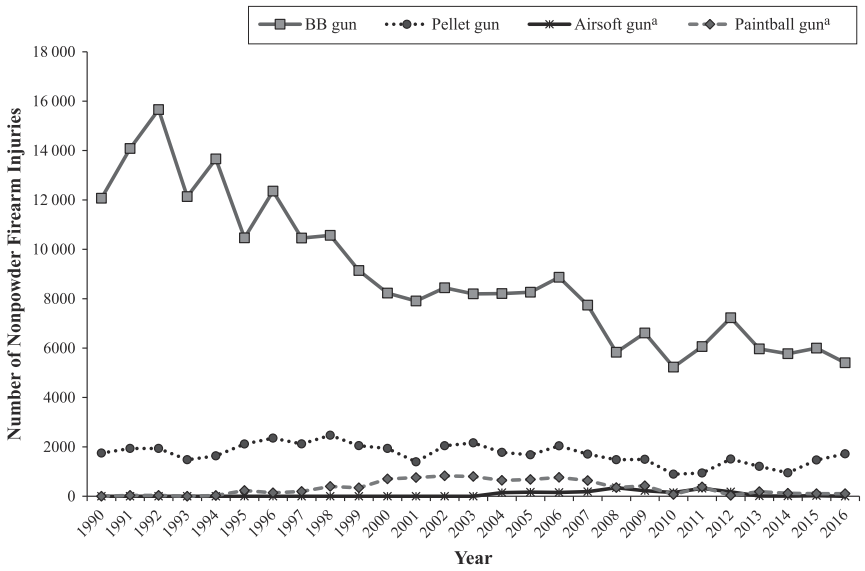

FIGURE 2
Estimated annual number of children treated in US EDs with a nonpowder firearm injury by type of firearm (NEISS 1990–2016). [a] Potentially unstable estimates because the sample is <20, estimate is <1200, or coefficient of variation is >33%.

injuries often focus on the use of appropriate eye protective equipment, with 1 study estimating that eye protection was absent in >98% of eye injuries.[6] Voluntary safety standards exist for eye protective equipment for paintball and airsoft guns.[28,29] A policy statement by the American Academy of Pediatrics provides specific recommendations for protective eyewear for children participating in various sports and recreational activities, including use of nonpowder firearms.[30]

Unlike powder firearms, which fall under the oversight of the Bureau of Alcohol, Tobacco, Firearms, and Explosives within the US Department of Justice, the CPSC has federal jurisdiction over nonpowder firearms. Although the CPSC has no mandatory safety regulations for nonpowder firearms, 2 voluntary safety standards have been adopted, American Society for Testing and Materials (ASTM) F589 Standard Consumer Safety Specification for Non-Powder Guns and ASTM F590 Standard Consumer Safety Specification for Non-Powder Gun Projectiles and Propellants.[8,13] Manufacturers are extensively involved in the development of ASTM voluntary standards and generally comply with the safety specifications included in the standards.

Despite the lack of federal mandatory safety standards for nonpowder firearms, 23 states and the District of Columbia have adopted laws to address the safety concerns of these products. In addition, local jurisdictions such as New York City, have passed their own ordinances.[5] The 4 major categories of state regulations include (1) defining nonpowder firearms as firearms (New Jersey and Rhode Island), (2) defining certain high-power or large caliber nonpowder firearms as firearms (Illinois and Michigan), or (3) defining nonpowder firearms as dangerous weapons (Connecticut, Delaware, and North Dakota). Each of these definitions carry restrictions on the purchase, transfer, possession, or use of the nonpowder firearm, which vary by state. The fourth category of state regulation restricts access by children. Most state regulations fall into this last category, vary greatly by state, and frequently can easily be circumvented with parental consent or adult supervision. Variability includes the age cutoff for these regulations, some applying to children <18 years of age and others applying to those as young as <12 years of age.[5]

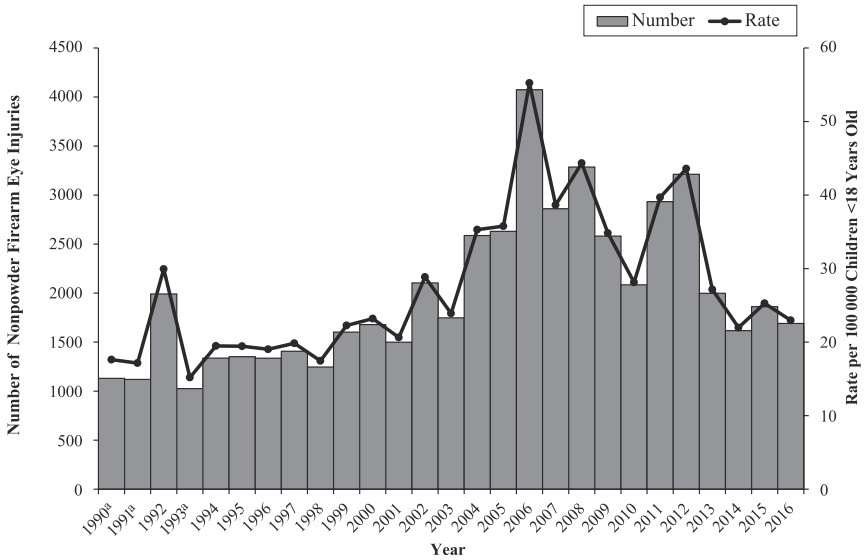

FIGURE 3
Estimated annual number and rate of nonpowder firearm eye injuries (NEISS 1990–2016). [a] Potentially unstable estimates because the sample is <20, estimate is <1200, or coefficient of variation is >33%.

This study has several limitations. The number of nonpowder firearm injuries is underestimated by the NEISS because it only includes individuals treated in EDs and not in other health care settings, such as urgent care facilities and private physician offices. Individuals treated in EDs also may not be representative of the entire spectrum of individuals with these injuries. NEISS case narratives may not consistently provide information about the user of the firearm, whether the injury was intentional or unintentional, and other details of the injury incident; however, all narratives were individually reviewed to ensure, to the best of our ability, that each case was categorized appropriately. There were no fatalities in this study; however, the NEISS does not capture fatal injuries well, so we are unable to comment on fatal injuries associated with nonpowder firearms on the basis of this database. We did not have access to pediatric nonpowder firearm exposure data; therefore, US population data were used to calculate injury rates. Despite these limitations, this study provides a comprehensive epidemiological investigation of pediatric nonpowder firearm injuries over a 26-year study period by using a nationally representative sample.

CONCLUSIONS

Although the number and rate of nonpowder firearm injuries declined during the study period, nonpowder firearms remain a frequent and important source of preventable and often serious injury to children. The severity and increasing rate of eye injury related to nonpowder firearms is especially concerning. Increased prevention efforts are needed in the form of stricter and more consistent safety legislation at the state level, as well as in child and parental education regarding proper supervision, firearm handling, and use of protective eyewear.

ABBREVIATIONS

ASTM: American Society for Testing and Materials
CI: confidence interval
CPSC: US Consumer Product Safety Commission
ED: emergency department
NEISS: National Electronic Injury Surveillance System
OR: odds ratio

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