



Administration of Emergency Medicine

CHARACTERISTICS AND COSTS OF PEDIATRIC EMERGENCY DEPARTMENT VISITS FOR SPORTS- AND RECREATION-RELATED CONCUSSIONS, 2006–2014

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Abstract—Background: Although concussion-related emergency department (ED) visits increased after the passage of concussion laws, little is known about how the laws may disproportionately impact ED utilization and associated health care costs among children in different demographic groups. **Objective:** Our aim was to examine the patient and clinical characteristics of pediatric ED visits and associated health care costs for sports- and recreation-related concussions (SRRCs) before and after concussion law enactment. **Methods:** We retrospectively analyzed ED visits for SRRCs by children ages 5–18 years between 2006 and 2014 in the Pediatric Health Information System database ($n = 123,220$). ED visits were categorized as “pre-law,” “immediate post-law,” and “post-law” according to the respective state concussion law's effective date. Multinomial logistic regression models were used to assess the impact of the law on ED utilization. **Results:** The majority of visits were by males ($n = 83,208$; 67.6%), children aged 10–14 years ($n = 49,863$; 40.9%), and privately insured patients ($n = 62,376$; 50.6%). Female sex, older age, and insured by Medicaid/Medicare were characteristics associated with increased ED visits during the immediate post-law and post-law periods compared to their counterparts. A significant decrease in proportion of imaging use was observed from pre-law to post-law (adjusted odds ratio 0.49; 95% confidence interval 0.47–0.50; $p < 0.0001$). While annual adjusted costs per ED visits decreased, annual total adjusted costs per hospital for SRRCs increased from pre-law to post-law ($p < 0.0001$). **Conclusions:** Concussion laws

might have impacted pediatric concussion-related ED utilization, with increased annual total adjusted costs. These results may have important implications for policy interventions and their effects on health care systems. © 2019 Elsevier Inc. All rights reserved.

Keywords—concussion; ED utilization; healthcare cost; policy

INTRODUCTION

Sports- and recreation-related concussion (SRRC) is one of the most common injuries during childhood and adolescence, with an estimated 1.1–1.9 million concussions occurring each year among children aged 17 years or younger in the United States (1,2). SRRCs can have an immediate impact on brain function and can result in elevated risk for severe short- and long-term health consequences, such as second-impact syndrome or chronic traumatic encephalopathy (3,4). In the last decade, the increased number of reported SRRCs within the pediatric population has raised public health concerns (5). To help prevent SRRCs and reduce their consequences, all 50 states and the District of Columbia passed state youth concussion laws between 2009 and 2014. These laws focus on young athletes and include three main tenets: education of parents and athletes, mandatory

removal from play after a suspected concussion, and clearance to return to play by a licensed health professional (6).

Concussion laws are the first legal guidelines that mandate medical clearance for SRRCs before players return to play (6). An increase in concussion-related emergency department (ED) visits was observed after the passage of concussion laws, which may have been due to increased concussion awareness and recognition by clinicians, parents, and youth athletes (7–11). However, little is known about the extent to which concussion laws disproportionately impact ED utilization among youth in different social and demographic groups.

Moreover, while concussion legislation efforts have raised awareness and concussion symptom reporting, increased concussion recognition and mandated medical clearance may potentially lead to an increased burden on health care systems (12–14). Few studies to date have analyzed the impact of concussion laws on health care cost trends (10). Understanding the effect of concussion laws on the economic outcomes of pediatric concussions will help fill the knowledge gap by providing evidence of the burden that concussion treatment has on health care systems under governance by state concussion laws.

The aims of this study were twofold: to examine the changes in pediatric patient and ED clinical characteristics for SRRCs from pre-law to post-law, and to quantify the changes in annual adjusted cost per hospital and adjusted cost per visit associated with ED visits for SRRCs from pre-law to post-law. We hypothesized that increased proportions of ED visits for SRRCs in the pediatric population would be observed from pre-law to post-law for the following groups of individuals: female, older age, uninsured, and those not admitted to the hospital (15,16). We further hypothesized that increased ED visits for SRRCs would result in increased annual adjusted cost per hospital, but decreased adjusted cost per visit from pre-law to post-law.

Understanding the impacts of concussion laws on ED visits for SRRCs in the pediatric population by key patient and clinical characteristics, and the associated health care costs, will provide important information to both lawmakers and health care providers. This information will enable these groups to better prepare for effective health care delivery after law implementation that increases injury recognition and mandates medical evaluation.

MATERIALS AND METHODS

Study Data

Concussion visit data used for this study were obtained from the Pediatric Health Information System (PHIS), an administrative database of the Children's Hospital Association containing patient and clinical data from inpatient and select

outpatient (including ED) encounters from more than 45 tertiary care children's hospitals across the United States. The database also includes International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM) codes, which were used to identify ED visits for SRRCs that met eligibility criteria for this study (17–19). The state concussion law data were obtained from LawAtlas, a comprehensive public online portal that provides legislative information related to each state's concussion law, including each law's effective date (20).

Case Identification

In this study, ED visits for SRRCs were identified using the following criteria: 1) youth ages 5–18 years; 2) having at least one of the listed ICD-9-CM concussion diagnoses (310.1, 850, 850.0, 850.1, 850.10, 850.11, 850.5, 850.9, and 959.01); and 3) having a discharge date between January 1, 2006 and December 31, 2014. To ensure data quality, reporting of external causes of injuries and poisoning codes (e-codes) from ICD-9-CM was evaluated in each hospital-year. A total of 51,720 visits from hospital-years where e-codes were reported for <85% of all visits were excluded from this study. As an additional e-code data quality measure, 6355 visits were excluded because they did not include at least one ICD-9-CM e-code. We also excluded 78,895 visits that were not associated with a sports and recreation-related e-code. To ensure only true concussions were included, 742 visits were excluded because they contained ICD-9-CM codes for both concussion and moderate/severe traumatic brain injury (TBI), or the visit had indicators of a more severe injury (length of hospital stay longer than 1 day and use of mechanical ventilation or a stay in the intensive care unit). A final data set of 119,256 ED visits for SRRCs from 39 pediatric hospitals across 25 states, along with corresponding concussion law effective dates, was analyzed in this study. The study was approved by the Institutional Review Board of the authors' institution.

Study Variables

Time periods. To account for the variations in the effective date of each state's concussion law, we implemented standardized time periods for our analysis: pre-law, immediate post-law, and post-law. Hospital ED visits that occurred prior to the effective date of the respective state concussion law were defined as "pre-law" visits. Visits that occurred within 1 year after the effective date of the respective state concussion law were defined as "immediate post-law" visits. Visits that occurred more than 1 year after the effective date of the respective state concussion law were defined as "post-law" visits. Utilizing this approach, all ED visits were classified into

corresponding time periods based on the effective date of the state law listed for each ED visit.

Annual adjusted cost per hospital was defined as the median of total annual patient ED visit costs for SRRCs per hospital. Adjusted costs were based on the ratio of cost to charges submitted by the hospitals on their respective Medicare cost reports. Charges were then adjusted by the Centers for Medicare and Medicaid Services' wage/price index for the hospital's location, including further adjustments for inflation rates and geographic region (18).

Adjusted cost per visit was defined as the median of total patient costs per ED visit for SRRCs in a given hospital and year.

Patient characteristics included sex (male or female), age group (5–9 years, 10–14 years, or 15–18 years), race (white, black, Asian, American Indian, other, or unknown), ethnicity (Hispanic or Latino, not Hispanic or Latino, or unknown), and primary source of payment (private, Medicaid/Medicare, uninsured, or other).

Clinical characteristics included visit type (ED plus admitted or ED only) and imaging used, regardless of type (yes or no).

Statistical Analysis

We described frequencies and proportions of ED visits for SRRCs and tested the associations between patient and clinical care characteristics across the three periods using Pearson χ^2 tests or Fisher's exact tests. Multivariable multinomial logistic regression models were used to determine the unadjusted (UOR) and adjusted odds ratios (AORs) of ED visits for SRRCs, along with 95% confidence intervals (CIs), using the pre-law period as the reference group. UORs were calculated for patient characteristics, whereas AORs were calculated for clinical characteristics by adjusting for sex, age group, race, ethnicity, and primary source of payment.

We described the adjusted cost data (including annual adjusted cost per hospital and adjusted cost per ED visit) pertaining to all ED SRRC visits during the study period. Kruskal-Wallis test was used to test the differences in median adjusted costs across the three time periods due to skewed distributions, and Bonferroni correction method ($\alpha = 0.017$) was used for multiple comparisons. All data analyses were conducted using SAS, version 9.3 (SAS

Table 1. Patient and Clinical Characteristics of Emergency Department Concussion Visits by State Law Periods

Characteristic	Pre-Law, n (%)	Immediate Post-Law, n (%)	Post-Law, n (%)	All, n (%)	<i>p</i> Value*
Total	66,062 (100.0)	19,806 (100.0)	33,388 (100.0)	119,256 (100.0)	
Sex					0.0049
Male	44,727 (67.7)	13,452 (67.9)	22,299 (66.8)	80,478 (67.5)	
Female	21,314 (32.3)	6350 (32.1)	11,082 (33.2)	38,746 (32.5)	
Age group					<0.0001
5–9 years	21,115 (32.3)	5864 (30.0)	10,093 (30.6)	37,072 (31.4)	
10–14 years	26,353 (40.3)	8085 (41.3)	13,738 (41.6)	48,176 (40.9)	
15–18 years	17,870 (27.4)	5630 (28.8)	9174 (27.8)	32,674 (27.7)	
Race					<0.0001
White	42,132 (63.8)	12,631 (63.8)	20,549 (61.5)	75,312 (63.2)	
Black	14,206 (21.5)	4251 (21.5)	6704 (20.1)	25,161 (21.1)	
Asian	814 (1.2)	275 (1.4)	544 (1.6)	1633 (1.4)	
American Indian	138 (0.2)	33 (0.2)	104 (0.3)	275 (0.2)	
Other	4916 (7.4)	1977 (10.0)	4439 (13.3)	11,332 (9.5)	
Unknown	3856 (5.8)	639 (3.2)	1048 (3.1)	5543 (4.6)	
Ethnicity					<0.0001
Hispanic or Latino	6891 (10.4)	3105 (15.7)	7183 (21.5)	17,179 (14.4)	
Not Hispanic or Latino	39,870 (60.4)	14,332 (72.4)	22,214 (66.5)	76,416 (64.1)	
Unknown	19,301 (29.2)	2369 (12.0)	3991 (12.0)	25,661 (21.5)	
Primary source of payment					<0.0001
Private [†]	33,310 (50.4)	10,543 (53.2)	17,093 (51.2)	60,946 (51.1)	
Medicaid/Medicare	18,881 (28.6)	7260 (36.7)	12,083 (36.2)	38,224 (32.1)	
Uninsured [‡]	2762 (4.2)	831 (4.2)	1361 (4.1)	4954 (4.2)	
Other [§]	11,109 (16.8)	1172 (5.9)	2851 (8.5)	15,132 (12.7)	
Patient type					0.0435
ED + admitted	1420 (2.1)	393 (2.0)	770 (2.3)	2583 (2.2)	
ED only	64,642 (97.9)	19,413 (98.0)	32,618 (97.7)	116,673 (97.8)	
Imaging used					<0.0001
No	34,452 (52.2)	12,450 (62.9)	23,152 (69.3)	70,054 (58.7)	
Yes	31,610 (47.8)	7356 (37.1)	10,236 (30.7)	49,202 (41.3)	

ED = emergency department.

* Based on χ^2 tests.

[†] Private includes Blue Cross, HMO, PPO, TRICARE, or other commercial.

[‡] Uninsured includes self-pay or charity.

[§] Other includes Children's Health Insurance Program (CHIP), other government, other payor, hospital chose not to bill for encounter, and unknown.

Institute, Cary NC). Statistical significance was defined as a $p < 0.05$.

RESULTS

Patient and Clinical Characteristics of ED Visits for Sports and Recreation-Related Concussions by Law Periods

A total of 119,256 ED visits for SRRCs were included in this study, with 55.4% of the visits in the pre-law period, 16.6% in the immediate post-law period, and 28.0% in the post-law period, following standardization by respective state law effective dates (Table 1). More than two-thirds of the ED visits were by males (67.5%), 40.9% were by patients aged 10–14 years, and 63.2% were by whites. More than half of all visits were paid for by private insurance plans (51.1%), fewer than half (41.3%) were associated with use of imaging, and only 2.2% resulted in hospital admission.

Female sex ($p = 0.0049$), older age ($p < 0.0001$), non-white ($p < 0.0001$), Hispanic or Latino ($p < 0.0001$), or having Medicaid/Medicare insurance ($p < 0.0001$) was associated with increased ED visits for SRRC in the immediate post-law and post-law periods. In addition, a decrease in the proportion of visits resulting in hospital admissions was observed from pre-law to post-law ($p = 0.0435$). The proportion of imaging use also decreased, from 47.8% during the pre-law period to 37.1% and 30.7% in the immediate post-law and post-law periods, respectively ($p < 0.0001$).

Odds Ratio (OR) of ED Visits for Sports and Recreation-Related Concussions by Law Periods

Compared to males, females had greater odds of ED visits for SRRCs in the post-law period compared to those in the pre-law (UOR 1.04; 95% CI 1.01–1.07) (Table 2). Increased odds of ED visits for SRRCs were observed

Table 2. Odds Ratio for Patient and Clinical Characteristics of Emergency Department Concussion Visits by State Law Periods

Characteristics	Immediate Post-Law, UOR* (95% CI)	Post-Law, UOR* (95% CI)
Patient		
Sex		
Male	ref	ref
Female	0.99 (0.96–1.02)	1.04 (1.01–1.07)
Age group		
5–9 years	ref	ref
10–14 years	1.10 (1.06–1.15)	1.09 (1.06–1.13)
15–18 years	1.13 (1.09–1.18)	1.07 (1.04–1.11)
Race		
White	ref	ref
Black	0.99 (0.96–1.04)	0.97 (0.93–1.00)
Asian	1.13 (0.98–1.29)	1.36 (1.21–1.51)
American Indian	0.81 (0.55–1.18)	1.55 (1.20–2.01)
Other	1.34 (1.26–1.41)	1.84 (1.76–1.92)
Unknown	0.55 (0.51–0.60)	0.56 (0.52–0.60)
Ethnicity		
Hispanic or Latino	ref	ref
Not Hispanic or Latino	0.80 (0.76–0.84)	0.54 (0.52–0.56)
Unknown	0.27 (0.26–0.29)	0.20 (0.19–0.21)
Primary source of payment		
Private [†]	ref	ref
Medicaid/Medicare	1.21 (1.17–1.25)	1.24 (1.21–1.28)
Uninsured [‡]	0.95 (0.87–1.03)	0.96 (0.90–1.03)
Other [§]	0.33 (0.31–0.36)	0.50 (0.48–0.52)
Clinical		
	AOR* (95% CI)	AOR* (95% CI)
Patient type		
ED only	ref	ref
ED + admitted	0.87 (0.78–0.98)	1.04 (0.95–1.14)
Imaging used[¶]		
No	ref	ref
Yes	0.63 (0.60–0.65)	0.47 (0.46–0.48)

AOR = adjusted odds ratio; ED = emergency department; ref = reference; UOR = unadjusted odds ratio.

* ORs were calculated based on the multinomial logistic regression models, using the pre-law period as the reference group.

[†] Private includes Blue Cross, HMO, PPO, TRICARE, or other commercial.

[‡] Uninsured includes self-pay or charity.

[§] Other includes Children's Health Insurance Program (CHIP), other government, other payor, hospital chose not to bill for encounter, and unknown.

^{||} Adjusted by sex, age group, race, ethnicity, imaging used.

[¶] Adjusted by sex, age group, race, ethnicity, patient type.

among patients aged 10–14 years or aged 15–18 years (vs. aged 5–9 years), or having Medicaid/Medicare insurance (vs. private insurance). However, adjusted odds of ED visits for SRRCs with imaging use was decreased during the immediate post-law (AOR 0.63; 95% CI 0.60–0.65) and post-law periods (AOR 0.47; 95% CI 0.46–0.48), and for admitted patients during the immediate post-law period (AOR 0.87; 95% CI 0.78–0.98) (Table 2).

Annual Adjusted Costs per Hospital and Adjusted Costs per ED Visit by Law Periods

Overall, the median annual adjusted costs per hospital increased significantly from pre-law (\$151,217) to post-law (\$246,536) ($p = 0.0002$), although no significant difference was observed between the pre-law and the immediate post-law periods (\$163,970) ($p = 0.6042$) (Table 3). Increased trends in median annual adjusted costs per hospital were observed for ED visits paid for by Medicaid/Medicare plans, visits paid by private insurance, visits without hospital admission, and visits with no imaging use. However, for uninsured patients, admitted patients, or patients who used imaging, these costs

dropped initially in the immediate post-law period and then exhibited a greater increase in the post-law period compared to the pre-law period.

The median adjusted costs per ED visit exhibited a statistically significant decrease ($p < 0.0001$) from \$311 in the pre-law period to \$277 and \$284 in the immediate-post-law and post-law periods, respectively (Table 3). The results from the Bonferroni adjustment ($\alpha = 0.017$) for multiple comparisons showed statistically significant differences among pair-wise comparisons across the three periods. A decreasing trend in median adjusted costs per visit was observed for ED visits for patients with Medicaid/Medicare, private health insurance plans, or no insurance, with 10.9%, 11.8%, and 10.1% drops in median adjusted costs per visit from pre-law to post-law, respectively. However, these costs increased from pre-law to post-law for visits with subsequent hospital admission or imaging use.

DISCUSSION

In our evaluation of ED visits for SRRCs from a national pediatric hospital database, we investigated patient and

Table 3. Median Adjusted Costs of Emergency Department Concussion Clinical Characteristics by State Law Periods

	Pre-Law		Immediate Post-Law		Post-Law	
	n	Median (IQR), \$	n	Median (IQR), \$	n	Median (IQR), \$
Annual adjusted costs based on hospital level*	161	151,217 (88,797–328,148)	52	163,970 (78,966–301,582)	65	246,536 (137,741–410,142)
Primary source of payment						
Private [†]	152	67,464 (21,025–161,164)	49	89,710 (39,486–157,687)	63	128,651 (63,015–231,785)
Medicaid/Medicare	157	42,760 (20,704–76,774)	52	48,496 (18,517–124,658)	63	71,845 (44,050–147,390)
Uninsured [‡]	132	6014 (2876–16,239)	46	4119 (1668–13,578)	58	7422 (2844–15,512)
Other [§]	129	8546 (1771–50,132)	36	6805 (1864–22,824)	53	9590 (1852–43,490)
Patient type						
ED + admitted	145	37,224 (14,662–78,768)	47	25,795 (14,069–69,332)	59	48,848 (25,344–102,186)
ED only	158	113,254 (63,223–215,551)	50	122,338 (69,009–241,218)	63	193,120 (117,949–328,881)
Imaging used						
No	160	29,271 (10,251–51,004)	50	33,999 (15,979–68,857)	63	69,954 (33,663–87,996)
Yes	158	125,311 (72,748–269,625)	52	118,120 (50,468–256,620)	65	168,472 (86,104–311,546)
Adjusted costs per visit*	64,278	311 (157–593)	18,072	277 (159–582)	27,269	284 (177–625)
Primary source of payment						
Private	32,476	322 (175–604)	9639	264 (156–575)	13,813	284 (179–639)
Medicaid/Medicare	18,301	312 (161–590)	6572	293 (160–572)	9762	278 (171–599)
Uninsured	2658	326 (174–595)	736	319 (205–635)	1099	293 (171–643)
Other	10,843	243 (119–553)	1125	277 (163–723)	2595	311 (196–619)
Patient type						
ED + admitted	1395	4188 (2417–8164)	360	4834 (2824–10,144)	602	5853 (3309–10,520)
ED only	62,883	303 (155–571)	17,712	272 (159–554)	26,667	280 (173–595)
Imaging used						
No	33,048	185 (116–268)	10,716	181 (129–270)	17,033	194 (139–280)
Yes	31,230	577 (409–857)	7356	632 (416–1054)	10,236	719 (478–1137)

ED = emergency department; IQR = interquartile range.

* There are some missing cost data.

† Private includes Blue Cross, HMO, PPO, TRICARE, or other commercial.

‡ Uninsured includes self-pay or charity.

§ Other includes Children’s Health Insurance Program (CHIP), other government, other payor, hospital chose not to bill for encounter, and unknown.

clinical characteristics of visits before and after the concussion laws, and evaluated the associated costs. Our findings showed that females and Medicaid/Medicare-insured were associated with an increased proportion of ED visits for SRRCs in the post-law period compared to the pre-law period. Our results further showed that in the immediate post-law and post-law periods, annual adjusted costs per visit were decreased, while annual adjusted costs per hospital were increased. These findings suggest the concussion laws might have disproportionately impacted ED visits for SRRCs based on sex and primary source of payment, and added significant financial burden to our ED care system. Our findings could have implications for health care delivery regarding diagnosis and treatment of SRRCs.

Consistent with previous findings, we also found that pediatric ED visits for SRRCs were associated with decreased imaging use during the post-law periods, subsequently decreasing total hospital costs, which may have resulted, in part, from restrictions on computed tomography (CT) imaging use (10). Recent studies have shown that decreased CT imaging among pediatric ED visits for SRRCs occurred during time periods overlapping with state concussion law effective dates (21,22). A likely major contributor in recent years to this downward trend was the implementation of the Pediatric Emergency Care Applied Research Network (PECARN) rule, a validated prediction rule to avoid unnecessary CT scans for children who are at very low risk of clinically important TBI (22–25). Through reducing inappropriate pediatric CT imaging exposure, the PECARN rule may explain the decreased imaging use observed in the post-law periods. Conversely, a separate study by Gibson et al. documented no change in CT imaging use for pediatric concussion-related healthcare visits following passage of concussion laws; however, Gibson's study included more severe injuries than our study (26).

Our findings showed increased annual costs per hospital but decreased patient costs per visit during the post-law period, after accounting for economic changes in inflation and geographic region. These findings are supported by previous study findings that utilized the PHIS data set and showed a reduction in per-visit ED costs among pediatric concussion visits without CT imaging use (18). Our observed increase in total annual costs per hospital post-law could be due, in part, to an increased number and proportion of SRRC visits to pediatric EDs during this timeframe. Furthermore, the state concussion laws are targeted toward SRRCs, most of which are milder in nature. Our observed decreased cost per visit might therefore be explained by more patients with these less severe head injuries seeking ED care post-law, requiring only a few treatments or services during their

visit. Understanding the laws' impacts on visit costs and their burden on the health care system, an unintended outcome of the laws, will have important implications for concussion policy updates and improvements, and will enable EDs to prepare for effective pediatric concussion care.

Consistent with previously published studies documenting a growing trend in female representation among ED visits for sports-related concussions within the last decade, our study also showed an increased proportion of female SRRC patients during the post-law period (9,10,27). Previous research has conjectured that this increase in visits by females may be partly explained by greater sports participation among females in recent years, higher female concussion rates observed in gender-comparable sports, or greater health care-seeking behavior after concussions among females (13,28–30). Alternatively, another study found the law effects did not differ by sex; however, the study included only children covered by employer-provided and other commercial insurance plans (26). By including all visits, regardless of insurance type, our study included a larger sample size, which might be more sensitive when detecting any changes.

A greater proportion of pediatric ED SRRC visits paid by Medicaid/Medicare were in the immediate-post-law and post-law periods. Some studies have elucidated the frequent use of ED services among Medicaid/Medicare-insured pediatric patients; however, these same studies have not analyzed the impact of concussion laws on ED utilization by this specific group (31,32). A study by Arbogast et al. further showed that Medicaid patients were more likely to use the ED as an initial point of entry into a large pediatric care network for concussion compared to privately insured patients and self-pay (uninsured) patients (33). Though our results corroborate these findings, it is yet unclear how the effect of the concussion legislation might be moderated by the insurance type on health care choice and utilization among pediatric concussion patients. Comprehensive studies are needed to examine how mandated medical clearance may impact the patterns of health care use in concussed youth patients with different insurance plans.

Limitations

Our study is not without limitations. First, our study could have a potential misclassification between concussions and minor closed head injuries because we relied solely on existing concussion diagnosis codes to retrospectively define the concussion cases without information to confirm temporary loss of normal brain function. Second, the adjusted costs may include costs unrelated to concussion because this study's case definition allowed both

isolated and nonisolated concussions. Thus, procedures and treatments during a patient's visit, such as imaging, may have also been due to co-occurring injuries. For example, while a majority of the imaging techniques were "CT," many others were "plain radiography," which may have been used for injuries other than the concussion. Third, our data only included ED visits derived from tertiary care children's hospitals. Specialty outpatient clinics, primary care physicians, or other providers or ED visits from other hospitals were not included. Fourth, this study solely utilized law effective dates, and did not account for other variations or updates in the state concussion laws, or for other potential confounders that may have influenced our results. Finally, using ICD-9-CM e-codes to define SRRC, while highly specific, could lead to low sensitivity of our case definition. Such an approach also makes it impossible to distinguish between organized and recreational sport activities, although concussion laws might have more direct implications for organized sports than recreational activities.

CONCLUSIONS

In summary, our data offer a detailed look into the potential impact of U.S. concussion laws on current ED visit characteristics for SRRCs, and the associated health care burden. A greater understanding of these impacts can lead to more effective resource allocation by pediatric EDs, and can also inform policy makers when updating current concussion legislation or introducing new legislation that mandates medical evaluation. Further research is needed to prevent SRRCs among children and adolescents in order to reduce health care burden.

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ARTICLE SUMMARY

1. Why is this topic important?

Concussion-related emergency department (ED) visits increased following implementation of concussion laws. Understanding how these laws may disproportionately impact different demographic groups would help provide better care to concussion patients with different needs.

2. What does this study attempt to show?

This study attempts to show that children in different demographic groups (females, older age, and Medicaid/Medicare-insured patients) could be impacted differently by the concussion laws than their counterparts in terms of health care utilization and associated costs.

3. What are the key findings?

Our study found that females, older age, and Medicaid/Medicare-insured patients had increased ED visits for sports-and-recreation related concussions during post-law compared to their respective counterparts. Annual adjusted costs per ED visit decreased post-law, while annual total adjusted costs per hospital increased.

4. How is patient care impacted?

Our study findings can be used for more effective resource allocation in pediatric EDs, and could improve overall health care delivery and treatment outcomes. Further, these findings can inform policy makers of implications of legislation involving medical evaluation.