Initial Emergency Department Visit and Follow-Up Care for Concussions among Children with Medicaid

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Objective To describe the rates and patterns of initial emergency department (ED) encounters and follow-up care for concussions among Medicaid-insured children before and after the 2013 enactment of Ohio concussion law.

Study design Using a time-series design, this study analyzed concussion claim data obtained from Partners for Kids, a pediatric accountable-care organization in Ohio. A total of 12 512 concussions and 48 238 associated claims for services between January 1, 2008, and June 30, 2017, with an initial ED encounter among Medicaid-insured children (ages 0-18 years) were analyzed. The effect of the law on the odds of follow-up care were assessed using generalized estimating equations models, adjusted for sex, age group, and residence location.

Results Of the total 12 512 concussions, 63.9% occurred in male patients, 70.1% in patients ages 10-18 years, and 65.2% in patients from urban areas. The rate of initial ED encounters for concussions increased from 2008 to 2014 (2.8 to 4.9 per 10 000 members), followed by a decrease in 2016 (4.2 per 10 000 members). A significant increase in follow-up care after the initial ED encounter was observed from pre-law to post-law (OR 1.73, 95% CI 1.61, 1.86). A shift in follow-up care was observed from radiology and ambulance services in pre-law to primary care providers in post-law.

Conclusions The Ohio concussion law may have influenced the patterns of initial ED visit and follow-up care for concussions among Medicaid-insured children. Future studies evaluating the impact of the law should analyze the utilization patterns among children with various insurance/payment types. *(J Pediatr 2019;206:178-83).*

Mild traumatic brain injury (TBI), more commonly known as concussion, is a growing public health concern.[1] Among children younger than 15 years, pediatric TBI accounted for nearly 1500 deaths, almost 18 000 hospitalizations, and more than 640 000 emergency department (ED) visits in 2013 in the US.[2] At least 75% of all TBIs are classified as mild, minor, or concussions,[3] and most concussive injuries sustained by children occur during sports and recreational activities.[4] When a concussion is properly treated, most children and adolescents will return to their pre-injury level of functioning within 2-3 weeks of injury.[5] However, unmanaged concussions can have significant short- and long-term consequences, including prolonged symptoms, disrupted sleep, and impaired executive function and memory.[6,7] These consequences may be of particular concern in the pediatric population as their brains are still developing.[6,7]

To help mitigate the potential negative consequences of concussion, every state in the US passed a youth concussion law between 2009 and 2014.[8,9] These laws commonly include 3 core tenets: (1) immediate removal of an athlete from play if a concussion is suspected; (2) written clearance from a health professional for an athlete to return to play; and (3) education of athletes, coaches, and parents about concussions and the potential negative consequences of concussive injury.[9,10] Ohio's concussion law went into effect on April 26, 2013, and included the above 3 core tenets.[11] As these laws started to take effect, an increase in healthcare utilization has been reported,[12-15] largely because of an improvement in concussion recognition.[15] However, despite the growing number of studies examining the effects of youth concussion laws, studies that specifically analyze the trends of both initial healthcare utilization and follow-up care for concussions are sparse.[14-16]

Previous studies have shown that children with Medicaid are significantly more likely to use the ED for treatment of concussion than those without Medicaid.[17-19] Moreover, although concussion laws require medical clearance before return to play, most studies evaluating the impact of youth concussion laws have analyzed only patients' initial concussion visits,[12-14] with very few studies investigating the impact of the law on patterns of follow-up care during the course of concussion recovery.[20,21] The purpose of this study was to describe the rates and patterns of initial ED encounters and follow-up care for all-cause concussions among Medicaid-insured children before and after the enactment of Ohio concussion law. We

ED	Emergency department
PFK	Partners For Kids
TBI	Traumatic brain injury

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hypothesized that the rate of initial ED encounters for concussions would increase after the law went into effect. Likewise, we hypothesized that the number and proportion of follow-up care visits with primary care providers per injury would increase after the law went into effect.

Methods

This study used a time-series design to analyze claims data obtained from Partners for Kids (PFK). PFK is a pediatric accountable-care organization affiliated with Nationwide Children's Hospital located in Columbus, Ohio. PFK contracts with Medicaid-managed care plans in 34 counties in the central and southeast regions of Ohio to serve approximately 330 000 children ages 0-21 years.[22,23] The PFK claims database stores information on concussion-related claims including date and type of medical encounter(s), diagnosis, procedure(s), medication(s), and treating physician(s) and facilities. For the purpose of this study, health insurance claims submitted for services occurring from January 1, 2008, to June 30, 2017, were retrieved. This study was approved by the Institutional Review Board at the primary institution.

Study Sample and Inclusion Criteria

The study sample comprised children ages 0-18 years who were enrolled in Medicaid-managed care plans, diagnosed with a concussion, and presented to the ED for their initial medical encounter. Concussions were identified using the *International Classification of Diseases, Ninth and Tenth Revisions, Clinical Modification* codes for concussion: 850.0, 850.1, 850.11, 850.12, 850.2, 850.3, 850.4, 850.5, 850.9, and those beginning with S06.0.[12,24] Only actively enrolled PFK members at the time of initial and follow-up care who had 1 or more of the above concussion codes were included in analyses. To ensure healthcare utilization was truly related to concussion care, PFK members with co-occurring severe TBI diagnosis codes (2.84%) were excluded from this study.

To preclude members with any concussion-related medical encounters prior to their initial ED encounter, we included only concussion-related initial ED encounters that occurred on or after April 1, 2008, among children who had at least 30 days of continuous enrollment in PFK prior to their initial ED encounter. We also excluded any concussion-related medical encounters in the 90 days preceding the initial ED encounter. For patients with multiple ED visits, 30 days were required to have passed since a previous ED visit to categorize unique injuries.

To allow adequate time to seek follow-up care for concussions, we included only concussions with initial ED encounters occurring prior to December 31, 2016, to allow for inclusion of sufficient follow-up care visits by the end of the study period (June 30, 2017). This rigid criterion for the concussion case definition was used to reduce ambiguity regarding the clinical diagnosis and associated healthcare utilization for concussions.

Each patient may have had multiple concussions during the study period, each concussion had the potential to have multiple encounters, and each encounter could have included multiple medical claims. Thus, the final study sample included 11 813 unique patients, 12 512 unique concussions, 21 967 total encounters, and 48 238 total medical claims.

Main Measures

Monthly rate of initial ED encounters for concussions per 10 000 members, an injury-level variable, was calculated as the number of initial ED encounters among children with concussions in a month divided by the total number of PFK members in that same month, multiplied by 10 000. Yearly rates were calculated as cumulative sums of monthly rates in the respective calendar year. Sex- and age-specific rates were calculated using a similar method.

Follow-up care received, an encounter-level variable, was coded based on whether or not follow-up care was received after the initial ED encounter.

Type of follow-up care providers, a claim-level variable, was classified based on the medical specialty of the care provider(s) recorded in the provider-related medical claims. All medical claims for follow-up care were grouped into 9 categories: (1) ambulance service supplier, (2) emergency medicine, (3) radiology, (4) multispecialty clinic/group practice, (5) primary care provider, (6) sports medicine, (7) surgery, (8) other specialties, and (9) all others. The number and percent of claims in each group were calculated. For concussions with follow-up care, the first day and subsequent days of healthcare utilization were calculated separately.

The time presence of the law was measured as pre-law and post-law, based on the date the Ohio concussion law went into effect, April 26, 2013.[11]

Patient demographics included sex (male or female), age group (0-4 years, 5-9 years, 10-14 years, and 15-18 years), and location of residence (urban or rural based on the patient's billing zip code).

Statistical Analyses

The trends of monthly and yearly rates of initial ED encounters for concussions from pre-law to post-law were described. Monthly and yearly trends of initial ED encounters for concussions were also plotted by those with or without follow-up care. The type of claims for initial ED encounters and follow-up care were also analyzed within each medical specialty of the care provider and compared between pre-law and post-law time periods, using χ^2 tests. Generalized estimating equations models were used to assess the effect of the youth concussion law on the odds of follow-up care received, adjusting for sex, age and location of residence. The correlations of multiple injuries nested within each patient were also considered. All analyses were conducted in SAS v 9.3 (SAS Institute, Cary, North Carolina).

Results

Of 12 512 initial ED encounters for concussions included during the study period, 47.4% occurred pre-law and 52.6% occurred post-law (**Table I**). Male patients accounted for 63.9% of concussion-related initial ED encounters, and children ages

Table I. Patient and injury-level demographics

Characteristics	Total N (%*)	Pre-law n (%)	Post-law n (%)	*P* value†
Total patients	12 512 -	5934 (47.4)	6578 (52.6)	
Sex‡				
Male	8000 (63.9)	3827 (64.5)	4173 (63.4)	.1027
Female	4480 (35.8)	2075 (35.0)	2405 (36.6)	
Age (y)				
<5	1669 (13.3)	975 (16.4)	694 (10.6)	<.0001
5-9	2075 (16.6)	934 (15.7)	1141 (17.3)	
10-14	4428 (35.4)	1927 (32.5)	2501 (38.0)	
15-18	4340 (34.7)	2098 (35.4)	2242 (34.1)	
Healthcare utilization				
ED encounter without follow-up	6099 (48.8)	3335 (56.2)	2764 (42.0)	<.0001
ED encounter with follow-up	6413 (51.2)	2599 (43.8)	3814 (58.0)	
Area‡				
Urban	8157 (65.2)	3811 (64.2)	4346 (66.1)	.0438
Rural	4328 (34.6)	2104 (35.5)	2224 (33.8)	

*Column-percentages.
†*P* values were conducted by χ^2 tests.
‡There were 32 injuries with "null" sex, 27 injuries with "unknown" area.

10-18 years accounted for 70.1% of concussion-related initial ED encounters. Nearly two-thirds (65.2%) of concussion-related initial ED encounters occurred in children living in urban areas. Nearly one-half of the concussions (48.8%) had no associated follow-up care after the initial ED encounters.

Monthly and Yearly Rates of Initial ED Encounters for Concussions

The overall monthly and yearly rates of initial ED encounters for concussions increased significantly from pre-law to post-law, with 2.8 per 10 000 members in 2008 to 4.9 per 10 000 members in 2014, and then declined to 4.2 per 10 000 members in 2016. For concussion-related initial ED encounters without follow-up care, the monthly and yearly rates remained relatively stable from pre-law to post-law (**Figure**, B). However, for concussion-related initial ED encounters with follow-up care, the monthly and yearly rates of initial ED encounters for concussions increased significantly from pre-law to post-law, with annual rates of 0.8 per 10 000 members in 2008 to 2.9 per 10 000 members in 2014, followed by a decline, with a rate of 2.3 per 10 000 members in 2016 (**Figure**, A).

For both female and male patients, the patterns in yearly rates of initial ED encounters for concussions are similar with the highest rate observed in 2014, although male patients had consistently higher rates than female patients across the study period. Specifically, for male patients, the yearly rate of initial ED encounters per 10 000 members increased from 3.5 in 2008 to 6.1 in 2014, followed by a decline to 5.2 in 2016; for female patients the rate of initial ED encounters per 10 000 members increased from 2.0 in 2008 to 3.7 in 2014, followed by a decline to 3.2 in 2016. The rates of initial ED encounters for concussions increased from 2008 to 2016 for all age groups, with consistently highest rates across the study period in the 15- to 18-year-old age group compared with other age groups.

Patterns of Follow-Up Care

A significant shift away from providers for ambulance services and radiology and toward primary care providers was observed from pre-law to post-law (**Table II**). Specifically, compared with concussion-related initial ED encounters during the pre-law period, significant decreases in claims for ambulance-service providers ($P < .0001$) and radiology providers ($P < .0001$) were observed during the post-law period, and a significant increase in claims for primary care providers ($P < .0001$) was observed during the post-law period. In addition, when comparing types of follow-up care providers, similar patterns emerged as claims for radiology providers decreased significantly ($P < .0001$) post-law. Claims for sports medicine providers demonstrated no significant change for the follow-up care from pre-law to post-law ($P = .888$).

Follow-Up Care

A significant increase in follow-up care after the initial ED encounter was observed from pre-law to post-law, with aOR of 1.73 (95% CI 1.61, 1.86) (**Table III**). Male patients had 1.27 greater odds (95% CI 1.18, 1.37) of receiving follow-up care compared with females. Increased age was associated with greater likelihood of having follow-up care. Children living in rural areas had 0.87 lower odds (95% CI 0.81, 0.94) of receiving follow-up care compared with children living in urban areas.

Discussion

Legislation was recently passed in all 50 states and the District of Columbia requiring the strict reporting of concussion among youth athletes and medical clearance before returning to play.[9,10,12] Studies are beginning to assess the effects of these laws on the treatment of concussions for the general population. However, most studies to date have examined only the initial medical encounter when analyzing the impact of the law, and very few studies have been conducted among the Medicaid population.[14-17] This study analyzed patterns of both initial ED encounters and follow-up care for concussions in Medicaid-insured children before and after enactment of the Ohio concussion law. Our findings demonstrated an increase in the

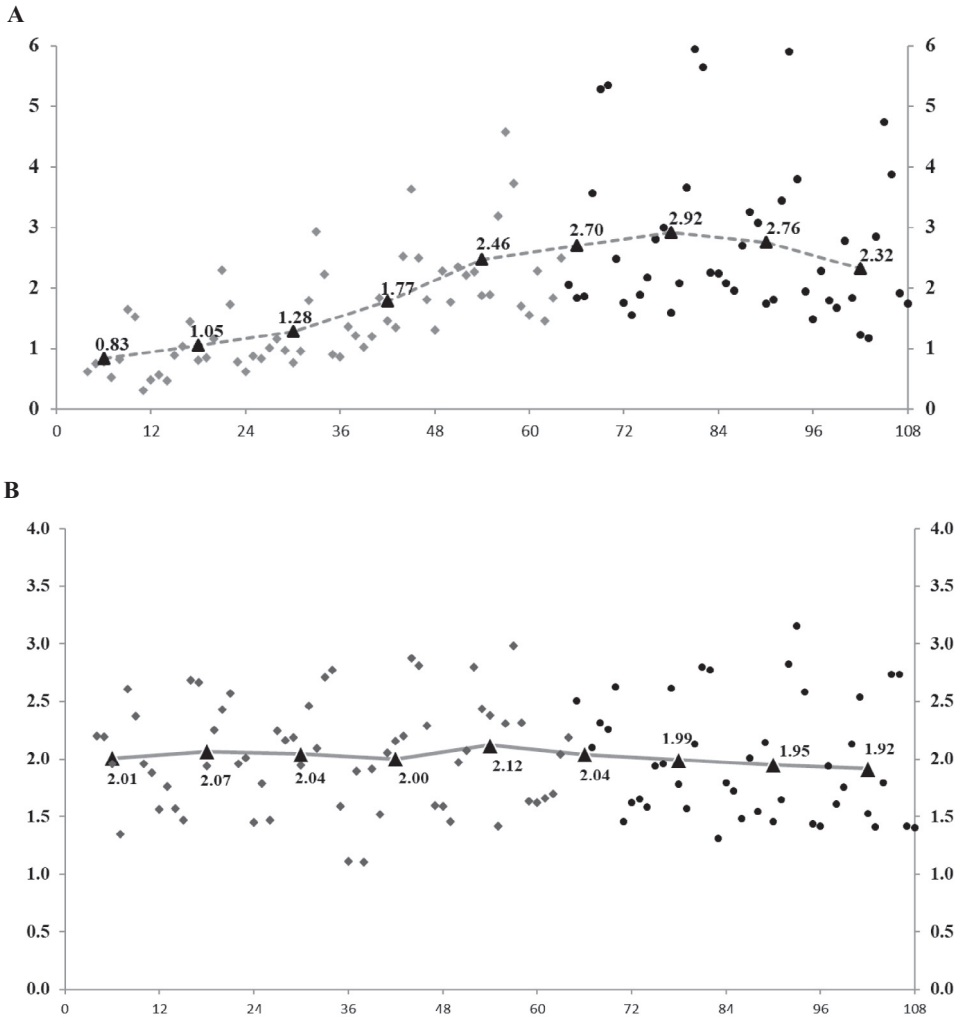

Figure. Rate of initial ED encounters (×10 000) vs time (months). **A,** With follow-up. **B,** Without follow-up.

monthly and yearly rates of initial ED encounters for concussions post-law, especially among those with follow-up care; a shift in follow-up care for concussions from radiology and ambulance services providers to primary care providers post-law; and an increase in follow-up care per injury post-law.

Our finding of increased initial ED encounters for concussions from pre-law to post-law is supported by the existing literature.[12-15] Although the intricacies of each law vary by state, each law includes concussion education and mandatory clearance by a healthcare professional before returning to play.[9,12] These stipulations likely contributed to the greater increase in the general public's concussion recognition, and subsequently, in initial ED encounters and follow-up care for all-cause concussions seen in the post-law years. Possibly, the reduced initial ED visits after 2016 could be due to reduced concussive injuries, decreased participation in high body contact sports (eg, football), or even non-adherence to the law.[25] Future studies should further examine the mechanisms associated with the reduction.[26]

Almost one-half of our study sample only had a single encounter following their concussion without any additional follow-up care. Although it is unclear why patients did not seek additional care, these patients may have initially visited the ED to confirm the concussion diagnosis. One of the core elements in every youth concussion law is educating parents, coaches, and athletes about concussions and their negative consequences.[9,10,12] This requirement likely prompted parents and athletes preemptively to seek treatment for more mild injuries which may have been previously overlooked. Patients who had only 1 follow-up encounter after their initial ED encounter may have received follow-up care from a physician in an athletic training room, or from a school athletic trainer, as authorized athletic trainers are approved to clear concussed athletes if the trainer meets the requirements of the Ohio concussion law (working under the supervision of or in consultation/collaboration with physician) and receive approval from a relevant governing authority (ie, school district board of education).[11] Because these physician and/or athletic trainer consultations do not result in medical claims, these follow-up assessments are not captured in our data. This may be explained by our results which found that the monthly and yearly rates of initial ED encounters for concussions

Table II. Initial ED utilization and follow-up care patterns for concussions before and after Ohio concussion law

	Claims for initial ED encounter		Claims for follow-up encounters	
	Pre-law (n = 5203)	Post-law (n= 3676)	Pre-law (n = 3958)	Post-law (n = 6806)
Medical specialty	n (%)	n (%)	n (%)	n (%)
Ambulance*	599 (11.5)	281 (7.6)	34 (0.9)	48 (0.7)
Emergency medicine	753 (14.5)	535 (14.6)	286 (7.2)	297 (4.4)
Radiology*,†	3078 (59.2)	1850 (50.3)	500 (12.6)	316 (4.6)
Multispecialty clinic/ group practice	104 (2.0)	115 (3.1)	28 (0.7)	93 (1.4)
Primary care provider*	208 (4.0)	317 (8.6)	2046 (51.7)	3383 (49.7)
Family practice	83	67	496	699
Internal medicine	25	43	95	118
Nurse practitioner	14	37	105	361
Pediatric medicine	86	170	1350	2205
Sports medicine‡	3 (0.1)	2 (0.1)	362 (9.1)	628 (9.2)
Surgery	151 (2.9)	85 (2.3)	247 (6.2)	214 (3.1)
Other specialties	68 (1.3)	19 (0.5)	288 (7.3)	539 (7.9)
All others	239 (4.6)	472 (12.8)	167 (4.2)	1288 (18.9)

*Medical specialty for initial ED encounter is significant comparing before and after law ($P < .0001$).
†Medical specialty for follow-up encounters is significant comparing before and after law ($P < .0001$).
‡Sports medicine at follow-up visit is not significant comparing before and after law ($P = .888$).

without follow-up remained quite stable from pre-law to post-law, although the rates for initial ED encounters for concussions with follow-up increased post-law. Furthermore, the higher rates of initial ED encounters among males compared with females, and among the 10- to 14-year-old and 15- to 18-year-old age groups when compared with the 0- to 4-year-old and 5- to 9-year-old age groups, are likely due to higher sports participation rates in these groups, which is consistent with previous study findings.[8,26]

The observed shift in type of healthcare provider encountered, specifically the decrease in claims for care by ambulance and radiology providers, can be partly attributed to the increased treatment of mild injuries at ED and/or the reduced reliance on imaging, which is needed only if a more severe TBI is suspected. Previous studies have demonstrated the Sport Concussion Assessment Tool–3rd edition (SCAT3) and ChildSCAT3 for children ages 5-12 years had a high sensitivity in measuring the signs and symptoms of concussions in an ED setting,[27,28] reducing the need for diagnostic radiology. Moreover, the Pediatric Emergency Care Applied Research Network has advised against the use of imaging in children without severe signs and symptoms, further decreasing the number of healthcare encounters in radiology post-law.[29] An increase in follow-up care after initial ED encounters post-law observed in this study, particularly with increased follow-up care with primary care providers post-law, can be partly attributed to increased concussion education and awareness. Parents have become more aware of the negative consequences of concussions, leading to a greater appreciation of the timeline for gradual return to play and/or the need for follow-up with a primary care provider for assurance of safe return to normal activities.[4,26]

Our study has several limitations. First, this study was unable to assess potential unmeasured factors, including trends in ED and related follow-up visits for all patients, that may contribute to our observed patterns of ED visits and follow-up care. Second, we were unable to determine the sequential order of multiple claims occurring on the same day because the time of the claim submission was not available. For example, if a patient had an ED claim and primary care claim on the same day, we were unable to determine which occurred first. Third, we used a "30 days" rule to determine new injuries for multiple ED visits. Although this rule was more conservative, some misclassification may have occurred. Fourth, only provider-related medical claims were used to classify the type of medical specialty providers. Because medical specialty was based on provider self-report, our categorization may be subject to potential misclassifications. Fifth, although patterns of initial ED visit and follow-up care visits may differ by mechanism of injury, patient age, and sex, this study failed to assess such differences. Finally, our results were based on Medicaid managed

Table III. Odds of follow-up care for concussion after initial ED encounter

	ED without follow-up n (%)	ED with follow-up n (%)	Unadjusted		aOR*	
			OR (95% CI)	*P* value	(95% CI)	*P* value
Legislation						
Pre-law	3335 (56.20)	2599 (43.80)	Ref		Ref	
Post-law	2764 (42.02)	3814 (57.98)	1.77 (1.65,1.90)	<.0001	1.73 (1.61,1.86)	<.0001
Sex†						
Male	3716 (46.45)	4284 (53.55)	1.29 (1.19, 1.38)	<.0001	1.27 (1.18,1.37)	<.0001
Female	2362 (52.72)	2118 (47.28)	Ref		Ref	
Age group (y)						
<5	1061 (63.57)	608 (36.43)	Ref		Ref	
5-9	1107 (53.35)	968 (46.65)	1.53 (1.34,1.74)	<.0001	1.38 (1.21,1.58)	<.0001
10-14	1942 (43.86)	2486 (56.14)	2.23 (1.99,2.51)	<.0001	2.02 (1.79,2.28)	<.0001
15-18	1989 (45.83)	2351 (54.17)	2.06 (1.84,2.32)	<.0001	1.96 (1.74,2.20)	<.0001
Area†						
Urban	3876 (47.52)	4281 (52.48)	Ref		Ref	
Rural	2212 (51.11)	2116 (48.89)	0.87 (0.80,0.93)	.0001	0.87 (0.81,0.94)	.0004

Ref, reference.
*Generalized estimating equations models were used to model of follow-up care (yes vs no), adjusting for sex, age, and residence location.
†There were 32 injuries with "null" sex, 27 injuries with "unknown" county.

care children in Ohio, which may not generalize to all Medicaid insured children or other populations.

Regardless, Ohio's concussion law has had an effect on the treatment course of concussed children with Medicaid in central and southeastern Ohio. After the law went into effect, the rate of initial ED encounters and follow-up care for concussions significantly increased. A significant shift in follow-up care showed an increased proportion of visits to primary care providers and a decreased proportion of visits with radiology and ambulance services care providers. Future studies using national data that include various insurance types are warranted to determine the impact of youth concussion laws on patterns of healthcare utilization. Future research should also investigate how a shift in healthcare utilization patterns may affect the changes in total costs attributable to concussion visits. ■

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