Analyzing the Effect of State Legislation on Health Care Utilization for Children With Concussion

Teresa B. Gibson, PhD; Stanley A. Herring, MD; Jeffrey S. Kutcher, MD; Steven P. Broglio, PhD, ATC

IMPORTANCE In 2009, Washington State enacted legislation outlining the medical care of children and adolescents with concussion (ie, the Lystedt Law), with all other states and Washington, DC passing legislation by January 2014.

OBJECTIVE To evaluate the effect of concussion laws on health care utilization rates from January 1, 2006, through June 30, 2012, in states with and without legislation.

DESIGN, SETTING, AND PARTICIPANTS For commercially insured children aged 12 to 18 years from all 50 states and DC from January 1, 2006, through June 30, 2009, we examined the following: (1) prelegislation trends in concussion-related health care utilization from January 1, 2006, through June 30, 2009, (2) postlegislation trends in states without concussion legislation, and (3) the effect of state concussion laws on trends in states with concussion legislation in effect by means of negative binomial multivariable estimation with state and time fixed effects.

EXPOSURES Concussion diagnosis.

MAIN OUTCOMES AND MEASURES Emergency department and related health care utilization rates for concussion.

RESULTS Between academic school years 2008-2009 and 2011-2012, states with legislation experienced a 92% increase in concussion-related health care utilization, while states without legislation had a 75% overall increase in concussion-related health care utilization during the same period. In the multivariable fixed-effects models, controlling for differences across states, rates of treated concussion in states without legislation were 7% higher in the 2009-2010 school year, 20% higher in the 2010-2011 school year, and 34% higher in the 2011-2012 school year compared with the prelegislation trends (2005-2009) (all \( P < .01 \)). During the same period, states with concussion laws demonstrated a 10% higher concussion-related health care utilization rate compared with states without laws (\( P < .01 \)).

CONCLUSIONS AND RELEVANCE Increased health care utilization rates among children with concussion in the United States are both directly and indirectly related to concussion legislation. A portion of the increased rates (60%) in states without legislation is attributable to an ongoing upward trend demonstrated before enactment of the first state law in 2009. The remaining 40% increase in these states is thought to have resulted from elevated awareness brought about by heightened local and national media attention. Concussion legislation has had a seemingly positive effect on health care utilization, but the overall increase can also be attributed to increased injury awareness.
port- and recreation-related concussions are estimated to occur between 1.6 and 3.8 million times a year in the United States. It is estimated that more than half these injuries go unreported, leaving the true incidence unknown. Following injury, patients show increased rates of self-reported symptoms, impaired motor function, and reduced cognitive functioning. When treated properly, most individuals with concussion will return to a preinjury level of functioning within 14 days. However, the long-term effects of concussion and noninjurious head impacts remain unclear. In addition, in adolescent athletes, there may be a risk for second-impact syndrome and significant neurological damage when a second concussive blow is sustained before resolution of the first.

The potential for significant worsening of the original injury, severe disability or death from second-impact syndrome, and the concern for chronic neurodegeneration prompted states to pass legislation outlining the medical care of children with concussion. Washington State enacted the first legislation in 2009 (ie, the Lystested Law). Similar legislation was passed by more than half the states and Washington, DC by the end of 2011, and all other states and DC had legislation in place by January 2014 (Table 1). The intricacies of each law differ by state, but most concussion legislation includes the following components: (1) education for coaches, parents, and/or athletes; (2) immediate removal of an athlete from play who has or is suspected of having a concussion; and (3) clearance from a health care professional for the athlete to return to activity no sooner than 24 hours following the injury. Concussion legislation is unique in medicine because no other injury has a legislative mandate requiring medical attention.

Because this is the first injury with legal guidelines outlining a medical intervention before returning to activity, how injury reporting and health care utilization are affected by such legislation is unknown. For instance, some have suggested that mandatory removal from activity and medical clearance before returning to activity would result in fewer reported cases because athletes would hide injuries to continue playing. Alternately, the legislation may result in increased interaction with medical professionals for injury diagnosis and/or clearance to return to activity. In addition to state legislative action, national awareness of sports concussion has increased through heightened media awareness and coverage. Therefore, the intent of this investigation was to evaluate health care utilization rates for concussions from January 1, 2006, through June 30, 2012, in states with and without legislation.

### Methods

The MarketScan Commercial Claims and Encounters (USA) Database (Truven Health Analytics) was analyzed from January 1, 2005, through June 30, 2012 (the latest information available). MarketScan is derived from health insurance claims and contains deidentified information from all settings of care (inpatient and outpatient) from various health plans and employersponsored plans, including health maintenance organizations, point-of-service plans, and consumer-directed health plans. In 2012, MarketScan contained information from approximately 50 million enrollees in the United States.

The study group comprised insured children aged 12 to 18 years, the age group most likely to be affected by concussion legislation. These children were selected from a continuous cohort of 96 employer and health plan data contributors from January 1, 2005, through June 30, 2012, to minimize changes in the underlying composition over time. Data collected from all 50 states and DC were used in the analyses. Claims from January 1, 2005, through December 31, 2005, were used for prior utilization and enrollment patterns, while claims and enrollment data for services incurred in the 78 months from January 1, 2006, through June 30, 2012, were used in the analyses. Exempt status was provided by the University of Michigan Institutional Review Board.

To calculate monthly health care utilization rates for diagnosed concussions, we included children enrolled for health benefits in each month, with at least 12 months of continuous previous enrollment to enable assessment of prior utilization. For these children, a concussion was counted in a particular month based on the first day of medical service (not time of injury) and was preceded by at least 90 days without an additional concussion diagnosis. Concussions were defined using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes 850.0 through 850.9 (con- 
cussion) in the inpatient or outpatient tables diagnosis code fields, and we varied the definition in sensitivity analysis.

Health care utilization for concussion-related events included outpatient physician office visits, physician office visits to specialists (ie, neurologists), emergency department (ED) visits, and inpatient admissions. Visits or admissions were concussion related if a concussion diagnosis code was included. Although not commonly indicated, we also measured rates of computed tomographic (CT) scans for concussion to assess trends in imaging services.

We assessed the following: (1) prelegislation trends in concussion-related health care utilization from January 1, 2006, through June 30, 2009, (2) postlegislation trends from July 1, 2009, through June 30, 2012, in states without concussion legislation in effect, (3) the effect of state concussion laws on concussion-related health care utilization trends in states with and without concussion legislation in effect. Risk ratios and 95% CIs were adjusted for...
state characteristics, such as median income, percentage unemployed, and percentage female, by means of negative binomial multivariable estimation with state and time fixed effects, including an offset for the number of enrolled individuals in each month (see eAppendix in the Supplement for model specification and sensitivity analysis\textsuperscript{12}). In this specification, dummy variables control for time-invariant state-specific factors. The adjusted estimates were subtracted from 1 to obtain the adjusted rate increase or reduction.

Data on health care utilization rates for bone fractures, an injury unlikely to be affected by the legislation, were also extracted from the MarketScan database and analyzed as a falsification test, in which an absence of effects is expected. A finding of no association between fracture rates and concussion legislation further strengthens the evidence that the estimated effects on concussion rates are associated with the legislation and not with unobserved state-specific characteristics.

### Results

By the end of the 2011-2012 school year (mid-2012), 35 states (70.0%) plus DC had laws in effect regarding sports-related concussion in children (Table 1). These states represented 62.0% of children aged 12 to 18 years who met the study inclusion criteria in the MarketScan database, with the remainder (38.0%) residing in states without legislation.

As noted in Table 2, before the enactment of state concussion laws, the rate of treated concussions rose from 4.98 per 1000 children (annualized rate) in early 2006 to 7.15 per 1000 children in the 2008-2009 school year. This was a 43.6% increase, or an approximately 9.4% increase per year. In the 2009-2010 school year, the first with state legislation in effect, the rate of treated concussions increased to 8.49 per 1000 children. In 2010-2011, the rate increased to 10.64 per 1000 children, and in 2011-2012, it almost doubled from prelegislation (2008-2009) levels to 13.27 per 1000 children.

Health care utilization for unadjusted annualized rates of concussive events followed a cyclical pattern each year, with the lowest rate of concussions occurring in July (eg, 3.52 per 1000 children in 2008) and the highest rates occurring in September (eg, 8.51 per 1000 children in 2008) and October (eg, 8.92 per 1000 children in 2008) (Figure). Rates of treated concussions were rising by 9% before the enactment of the first state legislation. After 2009 and the passage of the first state laws, states without laws in effect demonstrated a 20.9% annual increase in treated concussion rates. In states with legislation in effect, the rates of treated concussions were higher by an average of 13.1% per year than in states without laws in effect.

---

### Prelegislation and Postlegislation Trends in Health Care Utilization for Concussions

In the multivariable fixed-effects models, controlling for differences across states, the rates of treated concussions increased 9% per school year ($P < .01$) before the first concussion law (ie, 2005-2009). Following the implementation of concussion legislation in 2009, the rates of treated concussions in states without legislation were 7% higher in the 2009-2010 school year, 20% higher in the 2010-2011 school year, and 34% higher in the 2011-2012 school year (all $P < .01$) than prelegislation trends (2005-2009).

When health care utilization for concussions was evaluated based on the presence of concussion legislation, a 10% increase in health care utilization for concussions was recorded in states with concussion laws in effect compared with states without laws in effect ($P < .01$).

### Concussion Event Rates by Sex

The effect on rates of health care utilization for concussive events after legislative action and in states with safety laws...
regarding concussion in children did not differ by sex, and rates were similar to the aggregate trend.

Office Visits
Concussion-related office visit rates increased by 20% per school year before the first concussion legislation (P < .01) (Table 3). When compared with the prelegislation trends, a 15% increase in office visits was seen in 2009-2010, a 43% increase in 2010-2011, and a 78% increase in 2011-2012 (all P < .01) relative to the 2008-2009 school year. From 2009 through 2012, the rate of office visits for concussion was 17% higher in states with laws in effect than in states without (P < .01).

Neurologist Visits for Concussion
The rate of neurologist visits during the prelegislation period from 2006 through 2009 remained unchanged (P = .26). However, relative to the 2008-2009 school year, a 36% increase in neurologist visits was noted in 2009-2010, an 84% increase in 2010-2011, and a 150% increase in 2011-2012 (all P < .01). The rate of neurologist visits for concussion were no different in states with and without laws in effect (P = .26).

ED Visits and CT Scans
Trends in ED visits and CT scans for concussion followed a similar pattern at each time point. The rates of concussion-related ED visits rose 9% per school year before the first concussion legislation, while concussion-related CT scans increased 7% during the same time (P < .01). Following the passage of concussion legislation, trends for ED visits and CT scans remained unchanged relative to the prelegislation time points (ED, P = .09; CT, P = .72). Similarly, ED visit and CT scan rates were no different in states with and without laws in effect (ED, P = .73; CT, P = .16).

Inpatient Admissions With Concussion
Prelegislation and postlegislation hospital admissions with concussion were stable over time (prelegislation trend, P = .66; postlegislation trend, P = .94; states with and without laws, P = .58).

Fracture Falsification Test
Before 2009, monthly trends in fracture and concussion rates were highly correlated (Pearson correlation coefficient, 0.93). Results of a falsification test of all bone fractures showed no change in fracture rates in all states after the first laws were in effect (postlegislation trend P = .23) and no difference between states with and without laws in effect (P = .054) (Table 3).

Discussion
During the previous decade, there has been a growing interest in the management of concussions, and beginning July 1, 2009, every state has enacted treatment legislation for the injury. This investigation sought to evaluate how legislative action and overall concussion awareness have altered utilization of medical services. Postestimation analysis indicated a 92% increase in health care utilization in states with concussion legislation between the 2008-2009 and 2011-2012 school years in children aged 12 to 18 years (eAppendix in the Supplement). In states without laws in effect, health care utilization for concussions increased 75% between the 2008-2009 and 2011-2012 school years. We estimate that slightly more than half (60%) the increase in states without laws in effect resulted from the continued trend of increasing health care utilization established before the first law was passed. The sources leading to the remaining 40% increase in utilization above the prelegislative trend were not evaluated, but it is not unreasonable to believe that general media coverage of laws from other states and/or the injury in general played a role. Indeed, a search of news articles from 2006 through 2012 using LexisNexis13 with the search terms sports AND concussion AND athlete showed a 6-fold increase during that time, which likely affected the health care utilization findings reported here.

While the absolute injury rate for concussions was lower in women, the rate of increase in health care utilization for concussions in women in the prelegislative period was twice (10%) the rate of increase in men (5%) (Table 4). Interestingly, the effect of legislation was similar by sex, despite data supporting...
the notion that women sustain concussion more frequently than their male counterparts.14

One of the major concerns in treating athletes with concussion, particularly child athletes, is a premature return to play that leads to an additional head impact while still recovering from an injury. Indeed, a national investigation of sport-related concussion reported that more than 90% of individuals who received a repeated injury did so within 10 days of the first concussion.15 Certainly most of these individuals returned to play before full resolution of the first injury. Although it was beyond the scope of this investigation to evaluate the effects of state legislation on repeated concussions, we would expect that the increased use of physicians through office (78% increase) and neurologist (150% increase) visits has resulted in better management and longer recovery times before returning to participation. Encouragingly, the rate of concussions managed through the ED remained unchanged following the implementation of state laws, suggesting that those who seek medical care for the injury are doing so through the appropriate channels. Use of CT scans for concussion management also remained unchanged. This finding is consistent with clinical algorithms for CT use16 and epidemiological studies that show low rates of vomiting17 and loss of consciousness.18

This study is not without limitations. Most important, the cause of injury is not reported in the insurance claims. While we assume that most of the injuries and the subsequent increase starting in 2009 are associated with sporting activity, some may have resulted from other activities (eg, automobile accidents). However, we have no reason to believe concussion reporting rates not associated with sports increased during the same period. There is also no reason to believe that the true incidence or injury rates for concussion have increased since 2009—results of a falsification test of fractures, for which the absence of an effect is anticipated, showed no postlegislation change in rates in states with or without concussion laws. Since then, there have been no substantial changes to sporting rules that would result in increased concussion rates. Rather, sporting organizations have placed increased emphasis on reducing concussions through athlete education, rule changes, and increased penalties for actions that place players at risk for concussion. Second, the effective dates we analyzed represent the latest date the legislation was determined to be effective. In many states, the legislation was effective shortly after enactment; however, several states had a phased implementation of the legislation and provisions of the law could unfold over several months. We believe that selecting a later date is likely to bias our results downward. Third, our study focuses on trends for children with employer-based health insurance, representing about half the children in the United States19; however, similar trends may not occur in children with public sources of insurance (eg, Medicaid) or uninsured children. Fourth, sports medicine physicians and physiatry specialty codes can be unevenly populated in administrative data, so we reported utilization of neurologist visits. This is likely to underestimate the rate of concussion-related specialist visits.

### Conclusions

The implementation of legislation dictating the treatment of concussions is unprecedented in the medical field. The implementation of legislation regulating concussive injury management appears to have been effective in increasing medical attention devoted to concussive injuries in children in the United States. From 2009 through 2012, states with legislation had a 92% increase in treated concussion-related health care utilization and states without legislation had a 75% increase.
Analytics, provided research assistance, and Andrew M. Bernard Jr, CPA, a former high school football coach, contributed assistance with the manuscript. We also thank seminar participants at Harvard Medical School, the Centers for Disease Control and Prevention, and Pennsylvania State University for their helpful comments and feedback. Mr Allen and Ms Imshaug contributed to the study through their affiliation with Truven Health Analytics and received financial compensation. No others received financial compensation.

REFERENCES