Interrupted time Series Design to Evaluate ICD-9-CM to ICD-10-CM Coding Changes on Trends in Colorado Emergency Department visits Related to Traumatic Brain Injury

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Short Report

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Abstract

Background. The transition in 2015 to the Tenth Revision of the International Classification of Disease, Clinical Modification (ICD-10-CM) in the USA led public health professionals to propose a surveillance definition of traumatic brain injury (TBI) that uses ICD-10-CM codes. The proposed definition excludes "unspecified injury of the head," previously included in the ICD-9-CM TBI definition. The purpose of this study was to evaluate this change in surveillance methods on monthly rates of TBI-related emergency department visits in Colorado from 2012 to 2017.

Results. The monthly rate of TBI-related emergency department visits in the transition month to ICD-10-CM (October 2015) decreased 41 visits per 100,000 population (p-value <0.0001), compared to September 2015, and remained low through December 2017, due to the exclusion of "unspecified injury of head" (ICD-10-CM code S09.90) in the proposed TBI definition.

Conclusion. This study highlights a challenge in creating a standardized set of TBI ICD-10-CM codes for public health surveillance that provides comparable yet clinically relevant estimates over time. The findings inform estimation of TBI magnitude based on ICD coded data and decisions about allocating TBI resources based on an estimated TBI magnitude.

Background

Traumatic Brain Injury (TBI) is "caused by a bump, blow, jolt, or penetration to the head that disrupts normal function of the brain."[1] In Colorado, TBIs contributed to 13 percent of all injury-related emergency department (ED) visits from 2012–2014 based on healthcare billing data coded in the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM).[2] On October 1, 2015 the US implemented the tenth revision to the ICD-CM. Proposed surveillance methods of TBI-related emergency department (ED) visits do not utilize ICD-10-CM code S09.90 for "unspecified injury of the head." Epidemiologists at public health organizations in the US use ICD-coded billing data for surveillance of TBI.[1] The purpose of this study is to assess the impact of the exclusion of S09.90 in the transition to ICD-10-CM on TBI surveillance in Colorado.

Methods

The study team analyzed administrative billing data on ED visits for Colorado residents treated and released in Colorado non-federal, acute care hospitals from January 1, 2012 through December 31, 2017. Study staff searched all 30 discharge diagnoses fields on each billing record for any of the TBI codes.

The ICD-9-CM codes used to identify TBI were: 800.0-801.9 (basilar skull fracture), 803.0-804.9 (other skull fractures), 850.0-854.1 (intracranial injury, including concussion), 950.1-950.3 (injury to optic chiasm; optic pathways; visual cortex), 995.55 (shaken baby syndrome), and 959.01 (head injury, unspecified).[1,2] These ICD-9-CM codes do not include sequela of injury. The ICD-10-CM codes to identify

TBI were: S02.0, S02.1 (fracture of skull), S02.8, S02.91 (unspecified fracture of skull), S04.02, S04.03-, S04.04- (injury to optic chiasm; optic tract and pathways; visual cortex), S06- (intracranial injury), S07.1 (crushing injury of skull), and T74.4 (shaken infant syndrome).[4] The proposed ICD-10-CM codes for TBI do not include ICD-10-CM code S09.90 for "unspecified injury of head."[4] As ICD-10-CM codes designated the seventh character to indicate sequela (or other encounter types), ICD-10-CM codes for TBI and "unspecified injury of head" with a seventh character of "S", indicating sequela, were excluded from this study.[4]

Trends in crude monthly rate of TBI-related ED visits during the study period was assessed with two different estimation models. The first model utilized TBI rates based on the currently used ICD-9-CM and proposed ICD-10-CM codes. The second model utilized the same monthly rates for the ICD-9-CM period and TBI rates that included unspecified head injury (ICD-10-CM code S09.90) beginning in October 2015. The statistical model was a segmented regression using an interrupted time series design based on a detailed methodology in Slavova et al.[5] The analysis was conducted with SAS 9.4 and PROC AUTOREG to estimate autoregressive parameters with a BACKSTEP option to select the correct order of parameters in the autoregressive error model. The following regression model was used for analysis.

$$Yt = B0 + B1 * timet + B2 * ICD10CMt + B3 * time - after - ICD10CMt + \varepsilon t$$

Further explanation of regression model variables is provided in Slavova et al.[5]

Results

At the beginning of the study period (January 2012), the monthly rate of TBI-related ED visits per 100,000 population was 55.6 ($p < .0001$) with an average increase of 0.33 TBI-related ED visits per month ($p < .0001$). By the end of the ICD-9-CM coding era (September 2015), the monthly rate had increased to 70.3 ($p < .0001$).

Using the current surveillance methods with first estimation model, the monthly rate in the first month of the ICD-10-CM era (October 2015) was 29.3, a decrease of 41 visits per 100,000 ($p < .0001$), from the immediately prior month. After the ICD transition, the average monthly rate increase from October 2015 through December 2017 was 0.04 (Fig. 1), a decrease of 0.29 per 100,000 ($p = 0.0004$) from the ICD-9-CM era.

Figure 1. Monthly rates of TBI-related emergency department visits per 100,000 Colorado residents, 2012-2017[a]

[a]Figure 1 Footnote: Red dotted line on October 1, 2015 indicates the start of ICD-10-CM in the United States. Traumatic brain injury (TBI) estimates after the transition to ICD-10-CM (marked by red dotted line) do not include unspecified injury of head.

Using the second estimation model with inclusion of ICD-10-CM code S09.90, the transition to ICD-10-CM in October 2015 was not significant ($p = 0.94$). The average monthly rate increase from October 2015 through December 2017 was 0.12, a decrease by 0.20 per 100,000 ($p = 0.04$) from the ICD-9-CM era.

Discussion

Utilizing the recommended ICD-9-CM and proposed ICD-10-CM codes for public health surveillance of TBI-related ED visits, this study found a large, immediate decrease of 41 visits in the monthly rate of TBI-related ED visits in October 2015, compared to September 2015.[1,3] This decrease represented over half of the monthly rate in September 2015. Upon addition of ICD-10-CM code S09.90, ("unspecified injury of the head") to surveillance methods, there was no longer a statistically significant decrease in monthly rates in October 2015. This finding suggests that the immediate decrease is due to the exclusion of code S09.90, which is not considered a traumatic brain injury clinically or in current surveillance methods. The average rate increase in TBI-related ED visits per month in the ICD-10-CM era increased with inclusion of S09.90 but remained smaller than in the ICD-9-CM era value.

Study limitations included not assessing other factors that could have influenced monthly TBI-related ED visit rates. This study did not assess whether training or other preparation for the ICD-10-CM transition influenced physician medical record documentation or the accuracy of billing diagnosis coding. Furthermore, ICD-CM codes are designed for billing purposes and have imperfect sensitivity and specificity when used for surveillance purposes.

Conclusions

This study shows the importance of understanding the diagnosis codes used to define monthly rates of TBI-related ED visits. The study findings inform estimation of a magnitude of TBIs based on ICD-10-CM coded data and decisions about allocating TBI resources based on an estimated TBI magnitude. The study results highlight challenges in creating a standardized set of TBI ICD-10-CM codes that both represent the clinical definition of TBI and are comparable over time. Using six years of ED billing data from a single state can inform the next steps for finalizing a public health surveillance definition of TBI until the next major change in the ICD-CM coding scheme.

Declarations

- ### Ethics Approval and Consent to Participate:

Not applicable

- ### Consent for publication:

Not applicable

- ## Availability of data and material:

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

- ## Competing Interests:

The authors declare that they have no competing interests.

- ## Funding:

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- ## Authors' Contributions:

BAG conceptualized the study and analysis plan and replicated the results. LAD and JJ implemented the analysis. All authors (LAD, BAG, and JJ) contributed to the interpretation of findings and drafting and revising the manuscript.

- ## Acknowledgements

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Figures

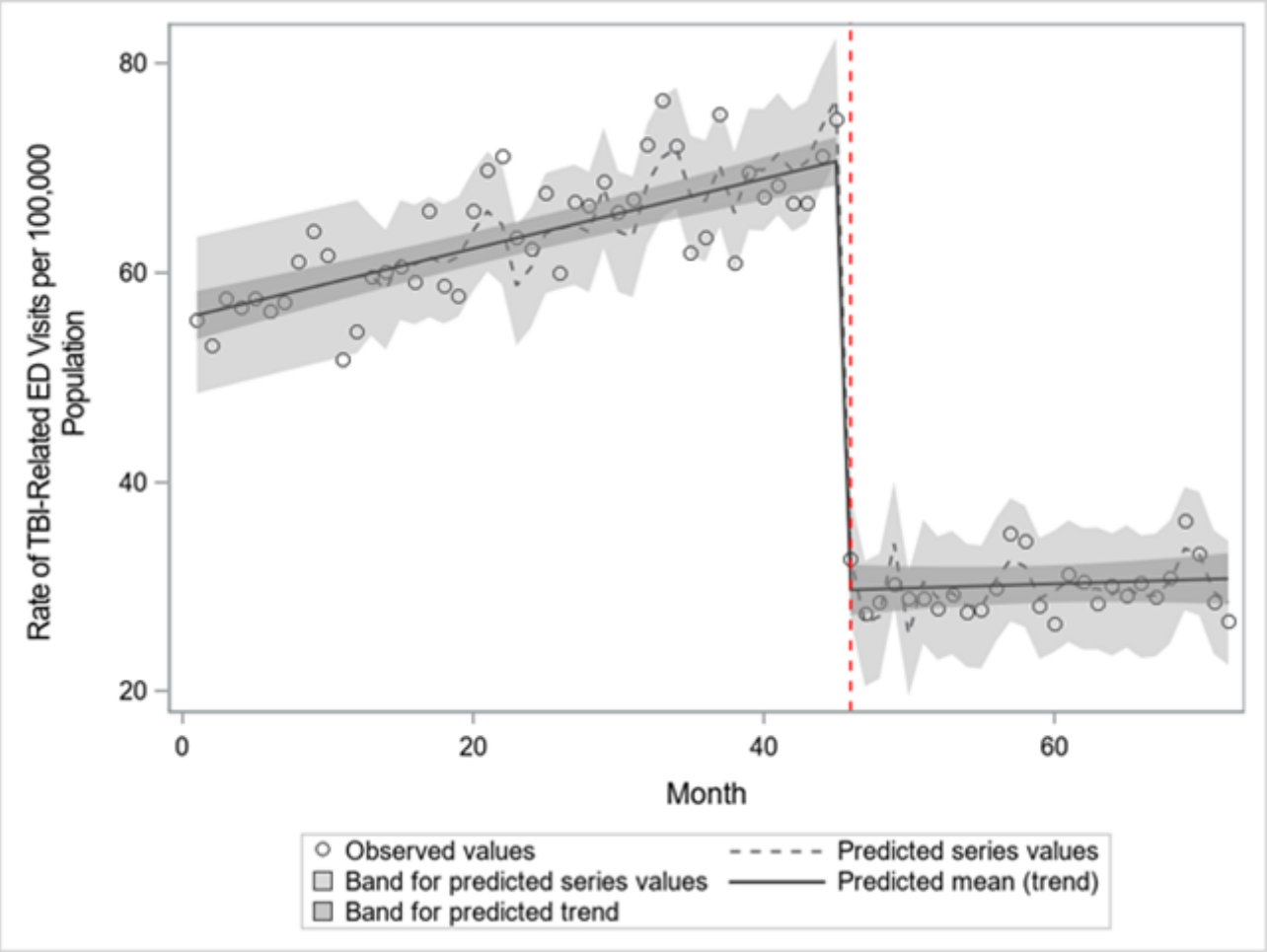

Figure 1

Monthly rates of TBI-related emergency department visits per 100,000 Colorado residents, 2012-2017a • Width: 170 mm • Maximum height: 127.5 mm • Image resolution: 330 ppi