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Costs of non-fatal traumatic brain injury in the United States, 2016

Gabrielle F. Miller, PhD,

Division of Injury Prevention, National Center for Injury Prevention and Control, CDC, 4770 Buford Highway MS S106-08, Atlanta, GA 30341, Phone: 770-488-5328, Fax: 770-488-1665

Lara DePadilla, PhD,

Division of Overdose Prevention, National Center for Injury Prevention and Control, CDC, 4770 Buford Highway NE, MS S106-08, Atlanta, GA 30341, Phone: 770-488-1568, Fax: 770-488-1317

Likang Xu, MD, MS

Division of Injury Prevention, National Center for Injury Prevention and Control, CDC, 4770 Buford Highway MS S106-08, Atlanta, GA 30341, Phone: 770-488-2854, Fax: 770-488-1665

Abstract

BACKGROUND: Traumatic brain injury (TBI) is a serious public health problem in the United States (U.S.). Each year, TBIs substantially contribute to healthcare costs, which vary by severity. This is important to consider given the variability in recovery time by severity.

RESEARCH DESIGN: This study quantifies the annual incremental healthcare costs of non-fatal TBI in 2016 for the U.S. population covered by a private health insurance, Medicaid, or Medicare health plan. This study uses MarketScan and defines severity with the abbreviated injury scale for the head and neck region (AIS-HN). Non-fatal healthcare costs were compared by severity.

RESULTS: The estimated 2016 overall healthcare cost attributable to non-fatal TBI among MarketScan enrollees was \$40.6 billion. Total estimated annual healthcare cost attributable to TBI for low severity TBIs during the first year post-injury were substantially higher than costs for middle and high severity TBIs among those with private health insurance and Medicaid.

CONCLUSIONS: This study presents economic burden estimates for TBI that underscore the importance of developing strategies to prevent TBIs, regardless of severity. Although middle and high severity TBIs were more costly at the individual level, low severity TBIs and head injuries diagnosed as “head injury unspecified” resulted in higher total estimated annual healthcare costs attributable to TBI.

Corresponding Author: Gabrielle F. Miller, PhD, Division of Injury Prevention, National Center for Injury Prevention and Control, CDC, 4770 Buford Highway MS S106-08, Atlanta, GA 30341, ygm3@cdc.gov, Phone: 770-488-5328, Fax: 770-488-1665.

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Keywords

TBI; Economic Burden; Cost

Introduction

In 2014, there were an estimated 2.5 million emergency department (ED) visits and 288,000 hospitalizations related to traumatic brain injury (TBI).¹ Estimates of lifetime medical costs of fatal, hospitalized, and non-hospitalized TBI among US citizens include \$14.6 billion in 2009 dollars² and \$11.5 billion in 2010 dollars.³ These estimates do not stratify by TBI severity level, which is an important factor to consider when assessing cost given that recovery times vary widely by severity level.^{4,5} A related element to identifying cost-effective prevention, treatment and management strategies is how incidence by severity level impacts our understanding of the economic burden in a broader population. Greater awareness of TBI in recent years may have led to increased identification and treatment,^{6,7} making an estimate employing more recent data and a methodology that stratifies TBI economic burden by severity level important.

This study estimated the annual incremental healthcare cost of TBIs among U.S. children and adults in 2016 during the year following a TBI diagnosis. We used a large claims database that includes employer-sponsored insurance, Medicaid, and Medicare and defined injury severity with the Abbreviated Injury Scale for the head and neck region (AIS-HN), an anatomy-based coding system that was developed to determine the severity of a specific injury.⁸ To our knowledge, there is not a current healthcare estimate for TBIs stratified by severity levels.

Methods

To estimate the annual incremental cost of nonfatal TBI, defined as the difference in healthcare spending between those with a non-fatal TBI diagnosis and those without a TBI diagnosis, we used de-identified IBM[®] MarketScan[®] Research Databases for private health insurance, Medicaid, and Medicare health plan enrollees in 2016. MarketScan data captures person-specific utilization, expenditures and enrollment for inpatient, outpatient, and prescription drug claims.

Diagnosed cases of non-fatal TBI were identified using ICD-10-CM codes, applying a standard approach based on a framework presented in 2016.^{9^a} An algorithm was developed as a crosswalk to map International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) codes to Abbreviated Injury Scale (AIS) severity scores.⁸ For this study, estimates are presented for grouped levels of severity. This analysis classified TBI severity using the maximum AIS-HN, for cases with more than one head or neck injury diagnosis. Consistent with a previous definition for stratification of TBI by severity,² injuries

^aS09.90 and S09.90XA, defined as unspecified injury of face and head, were included due to its inclusion in the mortality definition and previous inclusion of 959.09 in the ICD-9-CM definition (hereinafter referred to as head injury unspecified). TBIs due to shaken baby syndrome (ICD-10-CM code: T74.4) were excluded from this analysis, as too few were identified for meaningful analysis.

with an AIS score of 1 or 2 were classified as low severity, those with a score of 3 were classified as middle severity, and those with scores of 4, 5, or 6 were considered high severity. Injuries with codes based on the framework from 2016⁹ that were not assigned a severity level by the algorithm were grouped into a separate category (hereinafter referred to as severity not assigned). Additionally, head injury unspecified was grouped separately.

We included all patients with a visit in 2016 who were continuously enrolled with a non-capitated plan coverage during the 12-month study period. A matched case-control design was used to compare patients with TBI to patients without TBI. To account for baseline differences in demographics and healthcare resource use, those diagnosed with TBI were matched 1 to 1 to patients without a TBI using an exact match (online supplement). An index date was utilized as the start date of the study period for each patient (online supplement). Patients were followed for 12 months from their index date to determine costs. To capture co-morbidities, we used the Charlson Comorbidity Index^{10,11} to categorize patients with 0 (no comorbidity), 1-3, 4-5, and 6 comorbidities. For each database we matched on available variables. Enrollees with negative cost observations after aggregation of 12 months were excluded from the analysis as these might represent data entry errors or cost corrections. Additionally, patients enrolled in health maintenance organizations and capitated plans were excluded, as this analysis used expenditures at an individual level and these plans pay a fixed amount per member. Patients with multiple TBI diagnoses on the index date were classified based on the highest severity. Total healthcare cost was calculated by summing the cost for inpatient and outpatient care, and all prescription drugs. Total healthcare costs in the 12-month period following the index visit were compared between individuals with a TBI and matched comparison patients to determine the additional annual healthcare cost per patient due to the TBI (hereinafter referred to as the incremental cost difference).

Generalized linear models (GLM) (gamma family, log-link) were used to compare healthcare costs across severity levels. Regression models adjusted for match characteristics. Non-fatal costs were reported as the incremental cost difference for an individual with a TBI as compared to a matched individual without a TBI. Costs incurred were deflated to 2016 dollars using selected indices.¹² Weights were assigned to each patient to make it nationally representative (online supplement). Stata Version 15 (Stata Corp LP, College Station, TX) was used to conduct the statistical analysis.

Results

Table 1 reports the characteristics of patients with nonfatal TBI. Of the patients with TBI in the Medicare and Medicaid samples, 62.5% and 52.5%, respectively, were female. In contrast, 52.6% of TBI patients with private insurance were male. All patients with private health insurance were under 65, with 47.6% aged 0-17 years and 52.4% aged 18-64 years. A majority of patients in the Medicaid sample were aged 0-64 while 17.6% were aged greater than 65 years.

Table 2 reports the number of patients with a TBI diagnosis, the estimated incremental annual healthcare cost per patient, and the total annual healthcare cost attributable to TBI by

severity level and insurance type. There were almost 3 times more head injuries diagnosed as “head injury unspecified” compared to TBIs of low severity, and there were more than four times as many TBIs of low severity than TBIs of middle and high severity combined.

For all insurance types, the highest total estimated annual healthcare costs attributable to TBI were among patients who sustained a head injury diagnosed as “head injury unspecified.” Per-patient estimated incremental annual healthcare costs were lowest for TBIs classified as low severity, across all insurance types. Total estimated annual healthcare costs attributable to low severity TBIs were substantially higher than total estimated annual healthcare costs attributable to middle and high severity TBIs among those with private health insurance and Medicaid insurance. In contrast, the total estimated annual healthcare costs attributable to TBI for low and middle severity TBIs were similar for Medicare, with total estimated annual healthcare costs attributable to high severity TBIs being considerably lower compared to low and middle severity TBIs. In 2016, the total estimated annual healthcare spending attributable to non-fatal TBI among Medicaid, Medicare, and private insurance patients was more than \$40.6 billion. Just under 25% (\$10.1 billion) was incurred by private health insurance patients, while Medicare patients incurred over half of the total estimated annual healthcare cost attributable to TBI (\$22.5 billion) (Table 2).

Discussion

In this study, we found for non-fatal injuries that low severity TBIs, for which symptoms generally last only a short time,¹³ comprised the largest share of TBIs that could be categorized by severity and greater annual healthcare cost than middle and high severity TBIs among private health insurance and Medicaid patients. It is important to note, though, that it has been shown previously that moderate and severe TBI total healthcare costs are significantly higher than mild TBI during the second year after the injury;⁴ many who sustain a moderate or severe TBI experience protracted health difficulties including some with lifelong disability.¹⁴ The current study also found that the total estimated annual healthcare cost attributable to TBI for middle severity TBIs was greater than the total estimated annual healthcare cost attributable to TBI for low severity TBIs among Medicare patients in the first year after injury. Further research on economic burden could focus on the lifetime cost of TBI among all levels of severity and across insurance types.

A recent study in the United States found on average higher total one-year costs (\$13,564) for mild traumatic brain injury than the incremental one-year costs found in this study for TBIs of low severity in private health insurance and Medicaid.¹⁵ Important differences were that study included all costs rather than only those associated with the TBI and the sample included those over the age of 65 with coordination of benefits with Medicare, which were not included in the current study. The cost attributed to this age range was much higher than costs in the other age groupings.¹⁵ Finally, that study included ICD-9-CM code 310.2 (postconcussion syndrome), which is not part of the case definition for the current study in any severity level.

This analysis is subject to several limitations. First, an important limitation of the AIS severity measures based on ICD-10-CM codes is that head injuries coded only as “head

injury unspecified” (S09.90 and S09.90XA) are not assigned a severity level and these injuries represent the largest burden by cases and cost. A recent study of traumatic brain injury using MarketScan Database claims from 2004 to 2013 reported that 30% of index office or clinic visits included only this code, and acknowledged the need for future studies to explore the presentation and clinical course associated with its use.¹⁶ This study highlights the amount of cases and costs for which severity level cannot be assigned due to the limitations of applying an algorithm to administrative codes. Additionally, there are not well-defined consistent estimates for disability by severity level, and therefore it is not feasible to estimate the full economic burden of TBI to society, which would also include costs such as productivity losses for non-fatal TBI and caregiver costs.¹⁷ In addition, pediatric TBI may result in negative effects on school readiness,¹⁸ and this study could not account for those costs. This study is not representative of the United States population as it is a convenience sample of individuals enrolled in private health insurance plans, Medicare plans with an employee-sponsored supplemental plan, and a subset of state Medicaid plans. This study excludes patients without insurance coverage and those without 12 months of continuous enrollment, which may result in underreporting of the healthcare cost of TBIs. Additionally, these costs are restricted to those incurred in the year after the index date of the first TBI diagnosis in 2016 within the data source. Costs incurred more than 12 months after the index date of the TBI diagnosis are not included in these estimates.

Conclusion

This study presents economic burden estimates for TBI that underscore the importance of developing strategies to prevent TBIs, regardless of severity level. While low severity TBIs are more common, the toll of middle and high severity TBIs should not be understated due to the potential for long term consequences such as cognitive, behavioral, and physical deficits resulting in disability.^{13,19,20} Although TBIs of higher levels of severity result in much higher individual healthcare costs in the first year after a TBI, and have the potential to result in higher post-acute care costs, these data show that lower severity TBIs result in a higher total estimated annual incremental healthcare cost for those with private health insurance and Medicaid due to representing a greater proportion of the overall incidence of TBI. Additionally, head injuries for which severity cannot be assessed represent a significant cost as well, and determination of severity for these cases would aid in identifying areas to address for prevention. These estimates of the incremental annual healthcare cost, or the increased healthcare costs per year for a person with a TBI compared to a person without a TBI, highlight the value of primary prevention for TBI, including evidence based interventions to prevent some of the leading causes of TBI,¹ such as injuries from falls²¹ and motor vehicle crashes.²²

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1:

Characteristics of Patients with Traumatic Brain Injury^a, MarketScan^b Private health insurance, Medicare, and Medicaid Databases^c, United States, 2016

	Private Health Insurance n (%) ^d	Medicare n (%) ^d	Medicaid n (%) ^d
Total Enrollees (#)	845,508	738,238	490,258
Sex			
Male	444,607 (52.6)	276,608 (37.5)	233,030 (47.5)
Female	400,901 (47.4)	461,629 (62.5)	257,229 (52.5)
Region			
Northeast	209,379 (24.8)	193,339 (26.2)	N/R
North Central	197,660 (23.4)	161,929 (21.9)	N/R
South	280,190 (33.1)	259,012 (35.1)	N/R
West	158,279 (18.7)	123,957 (16.8)	N/R
Plan Type			
Comprehensive	32,408 (3.8)	394,687 (53.5)	486,901 (99.3)
Exclusive Provider Organization (EPO)	8,201 (1.0)	774 (0.1)	-
Point of Service (POS)	58,011 (6.9)	15,805 (2.1)	-
Preferred Provider Organization (PPO)	520,305 (61.5)	314,349 (42.6)	3,357 (0.7)
Consumer Driven Health Plan (CDHP)	116,528 (13.8)	2,357 (0.3)	-
High Deductible Health Plan (HDHP)	96,653 (11.4)	435 (0.1)	-
Missing	13,402 (1.6)	9,830 (1.3)	
Age			
0-17	402,604 (47.6)		165,672 (33.8)
18-64	442,904 (52.4)		238,293 (48.6)
>=65	-	738,238 (100.0)	86,293 (17.6)
Race			
White	N/R	N/R	289,510 (59.1)
Black	N/R	N/R	136,232 (27.8)
Hispanic	N/R	N/R	21,898 (4.5)
Other	N/R	N/R	9,454 (1.9)
Missing	N/R	N/R	33,164 (6.8)
Mental Health and Substance Abuse Coverage	779,879 (92.2)	725,701 (98.3)	490,258 (100.0)
Basis of Eligibility			
Aged Individual	N/R	N/R	65,367 (13.3)
Blind/Disabled Individual	N/R	N/R	155,468 (31.7)
Child (not Child of Unemployed Adult, not Foster Care Child)	N/R	N/R	149,682 (30.5)
Adult (not based on unemployed status)	N/R	N/R	92,068 (18.8)
Child of Unemployed Adult (optional)	N/R	N/R	311 (0.1)

	Private Health Insurance n (%) ^d	Medicare n (%) ^d	Medicaid n (%) ^d
Foster Care Child	N/R	N/R	3,724 (0.8)
Eligibility status Unknown (counts against error tolerance)	N/R	N/R	23,516 (4.8)
Individual covered under the Breast and Cervical	N/R	N/R	122 (0.0)

Note: N/R: not reported. Due to weighting characteristics may not sum to total.

^aTBI cases were identified using ICD-10-CM codes: S02.0, S02.1-, S02.8, S02.91, S04.02, S04.03-, S04.04-, S06-, S07.1, S09.90. T74.4 was excluded.

^bIBM Watson Health and MarketScan are trademarks of IBM Corporation in the United States, other countries or both.

^cPatients in HMO and capitated plans are not included here.

^dWeighted n's and percentages are presented. Weighted percentages may not add to 100 because of rounding.

Table 2:

Number of Patients with Traumatic Brain Injuries^a, Estimated Incremental^b Annual Healthcare Cost Per Patient, and Total Estimated^b Annual Healthcare Cost Attributable to TBI, by Severity - Marketscan Private health insurance, Medicare, and Medicaid Databases^c, United States, 2016

	Low- AIS severity 1 and 2	Middle- AIS severity 3	High- AIS severity 4, 5, and 6	Severity not Assigned	Head Injury Unspecified
	Number of Traumatic Brain Injuries (n) ^d				
Private health insurance	339,330	20,938	4,920	32,862	447,458
Medicare	75,085	55,255	6,262	20,745	580,890
Medicaid	87,427	22,204	4,269	41,501	334,857
Total TBIs	501,842	98,397	15,450	95,108	1,363,206
	Estimated Incremental Annual Healthcare Cost (Per Patient Cost (95% Confidence Interval)) ^e				
Private health insurance	\$4295 (\$4196 - \$4395)	\$9350 (\$9098 - \$9601)	\$34703 (\$32242 - \$37164)	\$40930 (\$34994 - \$46865)	\$15613 (\$14547 - \$16679)
Medicare	\$19445 (\$18883 - \$20008)	\$36149 (\$33242 - \$39056)	\$46653 (\$43054 - \$50253)	\$37684 (\$31251 - \$44117)	\$30930 (\$27848 - \$34011)
Medicaid	\$7010 (\$6807 - \$7214)	\$12995 (\$12305 - \$13685)	\$28471 (\$26101 - \$30841)	\$43523 (\$33728 - \$53318)	\$15420 (\$14477 - \$16364)
	Total Estimated Annual Healthcare Cost Attributable to TBI (n*Per Patient Cost) ^{d,e,f}				
Private health insurance	\$1,457,564,869	\$195,759,831	\$170,739,154	\$1,345,028,515	\$6,986,161,754
Medicare	\$1,460,063,115	\$1,997,408,575	\$292,143,716	\$781,757,899	\$17,966,701,153
Medicaid	\$612,886,875	\$288,538,316	\$121,541,290	\$1,806,243,043	\$5,163,615,489

TBI: Traumatic Brain Injury AIS: abbreviated injury scale for the head and neck region

^aTBI cases were identified using ICD-10-CM codes: S02.0, S02.1-, S02.8, S02.91, S04.02, S04.03-, S04.04-, S06-, S07.1, and S09.90. T74.4 was excluded. The severity of traumatic brain injury diagnoses was classified using the AIS-HN: score of 1 or 2 were classified as low, those with a score of 3 were middle, and those with scores of 4, 5, or 6 were considered high. Head Injury unspecified TBIs were those coded as S09.90 and S09.90XA. Consistent with the framework proposed in Hedegaard et al.¹

^bTotal healthcare costs in the 12-month period following the index visit were compared between individuals with a TBI and matched comparison patients to determine the additional annual healthcare cost per patient due to the TBI (Incremental costs)

^cNumber of TBI includes all plan types

^dWeighted n's are presented

^eEstimated Incremental Annual Healthcare costs were estimated in STATA using a GLM (gamma family, log-link) model.

^fTotal Estimated Annual Healthcare Costs attributable to TBI were calculated prior to rounding of per patient costs.