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Health and Health Care Utilization Outcomes for Individuals With Traumatic Brain Injury: A 1-Year Longitudinal Study

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Abstract

Objective: Traumatic brain injury (TBI) can result in new onset of comorbidities and limited studies suggest health care utilization following TBI may be high.

Setting, Participants, Mean Measures, and Design: This study used 2018 and 2019 MarketScan Commercial Claims and Encounters data to examine differences in longitudinal health outcomes (health care utilization and new diagnoses) by various demographic factors (age, sex, U.S. region, intent/mechanism of injury, urbanicity, and insurance status) among individuals with and without a TBI in the year following an index health care encounter.

Results: Results show that within 1 year of the initial encounter, a higher percentage of patients with TBI versus without TBI had at least one outpatient visit (96.7% vs 86.1%), emergency department (ED) visit (28.5% vs 13.1%), or hospital admission (6.4% vs 2.6%). Both children (33.8% vs 23.4%) and adults (43.8% vs 31.4%) who sustained a TBI had a higher percentage of new diagnoses within 1 year compared to the non-TBI group. Additionally, individuals with a TBI had greater health care utilization across all types of health care settings (outpatient and inpatient), visits (ED visits and hospital admissions), and across all demographic factors ($P < .001$).

Conclusion: These results may inform future research around the development of systems of care to improve longer-term outcomes in individuals with TBI.

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The authors declare no conflicts of interest.

Keywords

health care utilization; longitudinal; traumatic brain injury

TRAUMATIC BRAIN INJURY (TBI) is a significant public health burden in the United States. One recent large survey¹ found that 12.1% of adults self-reported a TBI in the past 12 months. National emergency department (ED) data² indicate that there were, on average, 3.8 million yearly ED visits for TBIs among children aged 5 to 18 years old in the United States from 2000 to 2019. These data demonstrate that millions of Americans are impacted by TBI annually.

TBIs can result in short- and long-term difficulties, such as headache, dizziness, and problems with memory, sleep, balance, and mood/behavioral changes³ and can impact an individual's quality of life and return to work, school, community involvement, and social participation.^{4–6} Because of the longer-term effects, TBI has been described as a chronic health condition,^{4,7} though more research is needed to better understand and characterize chronic post-injury issues and develop management and treatment approaches longitudinally and across the lifespan. Additionally, TBIs substantially contribute to health care costs as well. One study⁸ examined 2016 annual health care costs and estimated that total annual health care costs in the United States attributable to individuals 1 year after sustaining a TBI was \$40.6 billion.

Health care utilization of individuals with TBI in the United States is not well understood, though several studies suggest that health care utilization following initial TBI may be high compared to non-TBI trauma populations. For example, a study of children treated in the ED or hospital for TBI revealed a higher percent of subsequent ED revisits (33% vs 3%), rehospitalization (1% vs 0.4%), and mortality (0.05% vs 0.02%) during the first year following the TBI than non-TBI trauma patients.⁹ Risk factors for revisits and readmission included being an older child (15–17 years old), female, non-Hispanic Black, having government insurance or being uninsured, having a more severe injury, and sustaining a TBI through a fall or penetrating injury.⁹ Additionally, a study¹⁰ of adults that characterized health services utilization among individuals hospitalized with a TBI found increased utilization 1-year post-injury, as compared to 1 year pre-injury: 56% to 51% for ED revisits, 80% to 42% for readmissions, and 93% to 80% for outpatient visits. In particular, this study found a quarter of the individuals with a TBI in the sample accounted for most of these visits (75% quartile of the total number of visits) and were categorized as “superutilizers.”¹⁰ Furthermore, there is significant variation in who seeks follow-up care and where care is sought after a TBI, and no specific guidelines exist on the types of care and monitoring needed following the initial diagnosis.^{10,11}

New onset of long-term medical and psychological comorbidities has been associated with TBI, with accompanying negative impacts on functioning, community participation, and quality of life.^{4,6,9,12} For example, recent studies examining outcomes following TBI report lasting effects that include headaches, fatigue, cognitive changes, behavioral and participation changes, and new diagnoses for mental health conditions, such as depression and anxiety.^{4,6,9,12} Even when individuals are diagnosed with a mild TBI, evidence suggests

that although many recover quickly, between 24% and 48% can experience persistent symptoms 1 year post injury.⁶ Experiencing a TBI of any severity is also associated with risks of chronic cardiovascular, endocrine, neurological, and psychiatric comorbidities.¹³

There are relatively few comprehensive papers examining long-term health and health care utilization outcomes in persons with TBIs, and the studies that have examined these outcomes are often focused on a local area (ie, California⁹ or Indiana,¹⁰) used older data (more than 6 years old),^{9,14–18} or focused on a specific population (eg, children,⁹ limited to adults,^{10,18–20} or older adults.²¹) The goal of this study was to use a large dataset of commercial claims to examine differences in select longitudinal health outcomes (health care utilization and new diagnoses) by various factors (eg, age, sex, region, intent/mechanism of injury, urbanicity, insurance status) between individuals with a TBI and those without a TBI diagnosis in the year following TBI. We hypothesized that, compared to those without a TBI, individuals with a TBI would have significantly higher health care utilization (ie, outpatient visits, ED visits, and hospitalization admissions) and new diagnoses within 1 year of injury.

METHODS

Sample and data source

Data were analyzed using the 2018 and 2019 MarketScan Commercial Claims and Encounters (CCAE) database for the commercially insured population for both inpatient and outpatient claims. MarketScan captures person-specific utilization and enrollment for inpatient (patients admitted to the hospital) and outpatient claims (eg, emergency department visits, primary care visits, urgent care visits). The CCAE database includes data from active employees, early retirees, Consolidated Omnibus Budget Reconciliation Act (COBRA) continuees, and dependents insured by employer sponsored plans. While not nationally representative, the CCEA generally contains data on more than 25 million commercially insured beneficiaries each year across the United States.

Definition of TBI

Patients with TBI were identified using the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) codes: S02.0, S02.1, S02.80, S02.81, S02.82, S02.91, S04.02, S04.03, S04.04, S06, S07.1, and T74.4.²² Only initial encounters (which indicates a new injury) were included where the seventh character was “A,” “B,” or missing.²³ Patients who were diagnosed with a TBI in 2018 were considered to be patients with TBI and were followed for 1 year following the TBI.

Patient characteristics

Prevalence of selected demographic characteristics and outcomes for the TBI and non-TBI groups were calculated. Demographic characteristics included age group (0–17, 18–24, 25–34, 35–44, 45–54, and 55+ years), sex, region (northeast, north central, south, and west), urbanicity, and insurance status (comprehensive, preferred provider organization (PPO), and other). Other plan type is defined as Health Maintenance Organization (HMO), Exclusive Provider Organization (EPO), Point of Service (POS) with capitation, Consumer-Driven

Health Plans (CDHP), and High Deductible Health Plans (HDHP). Urbanicity was assigned using the metropolitan statistical area of the primary beneficiary. Beneficiaries were defined as residing in an urban area if their county of residence was classified as a metropolitan statistical area; beneficiaries residing outside of a defined metropolitan statistical area were considered to reside in rural areas.

Retrospective cohort study design

A matched retrospective cohort study design was used to compare patients with TBI to patients who did not have a TBI in 2018. Individuals were identified in 2018 if they had a TBI and matched to individuals in 2018 who did not have a TBI during the 2018 data year. Patients with a TBI were exact matched 1:1 to patients without a TBI on age, sex, region, mental health and substance abuse (MHSA) coverage indicator, insurance status, and month of index date to account for baseline differences in health care resource use. Patients without a TBI were randomly assigned an index date within 2018 that matched patients with a TBI, the index date was the date that the matched TBI patient was seen for the TBI.

Outcomes

New diagnoses among children (eg, learning disorders, attention-deficit/hyperactivity disorder, speech/language problems, developmental delay, bone/joint/muscle problems, anxiety problem) and adults (eg, diabetes, stroke, hypertension, alcoholism, drug addition, anxiety), as well measures of health care utilization (ie, outpatient visits, ED visits, and hospital admissions) were examined by TBI status and according to demographic characteristics in the year following an index health care encounter.

New diagnosis: New diagnoses were initially identified by previous literature^{24–27} that identified common comorbidities diagnosed after sustaining a TBI, stratified by children and adults. Then, Healthcare Cost and Utilization Project (HCUP) Clinical Classifications Software Refined (CCSR) for ICD-10-CM diagnoses, v2022.1 category codes with their descriptions were downloaded and 3 of the authors (D.W., J.H.K., and F.M.H.) each marked which categories were common diagnoses after an individual sustained a TBI, separated by child and adult. Next, a back-mapping of CCSR categories to individual ICD-10-CM diagnoses codes was conducted and a separate variable for the collection of these diagnoses for children and adults was created (Supplementary Digital Content, Table 1, available at: <http://links.lww.com/JHTR/A881>). New diagnoses were identified if there were no prior visits with any of the ICD-10-CM codes for patients 3 months prior to the initial TBI encounter and if there was a diagnosis within 1 year after the initial TBI encounter.

Outpatient visits, ED visits, and hospital admissions: Visits were classified as outpatient visits, ED visits, and hospital admissions. In MarketScan a patient may have multiple visits with a TBI, and each visit enters the dataset as a unique record. Each service date with a TBI code was considered a visit, and diagnosis codes for *outpatient visits* were defined by service date. *Hospital admissions* were considered an inpatient visit.

Statistical methods

We calculated counts and percentages of key demographic characteristics by TBI status. Additionally, t-test statistics were run for demographic characteristics and outcomes by type of health care utilization and TBI group. Effect sizes were also computed for each t-test using Cohen's d and interpreted in accordance with Cohen²⁸ to determine the associations' practical significance. An r of 0.2 represents a small effect size, an r of 0.5 represents a medium effect size, and an r of 0.8 represents a large effect size.²⁸ Of note, only associations with a medium effect size or greater will be described in the text (though all are available in the table). In addition, the 10 most common ICD-10-CM codes for new diagnoses assigned to patients were identified to show other diagnoses related to the visit. This was stratified by TBI/non-TBI group, then by outpatient/inpatient, and finally by children/adults, and prevalence was reported. Analyses were performed in Stata Version 17 (Stata Corp LP, College Station, TX). CDC human subjects' review of the protocol determined that it was not research involving human subjects. Thus, Institutional Review Board approval was not required.

RESULTS

Study sample characteristics

The descriptive statistics of the sample are reported in Table 1. Each sample contained 72,338 patients and prevalence for age, sex, region, and insurance type were identical by design. The majority of the sample were children (47.8%) and young adults 18 to 24 years of age (18.9%), and the sample was split evenly between males (50.6%) and females (49.4%). Around one-third of the sample (37.8%) lived in the South, the majority resided in an urban area (>89%), and approximately half had PPO insurance (51.5%).

Health care utilization, including outpatient visits, ED visits, and hospital admissions

Within 1 year of the initial index date, the majority of patients with TBI (96.7%) and matched non-TBI patients (86.1%) had at least one outpatient visit (Table 2). A greater proportion of patients with TBI, as compared to non-TBI patients had an ED visit in the year following the index date (28.5% and 13.1%, respectively). Among visits for children, 70.7% had a new diagnosis within 1 year of the initial encounter among individuals who were diagnosed with a TBI compared to 48.9% of non-TBI individuals. For visits among adults, 83.9% had a new diagnosis among the TBI group and 60.2% among the matched non-TBI group.

Table 3 summarizes the findings of health care utilization, including outpatient visits, ED visits, and hospital admissions. The percent of outpatient visits, ED visits, and hospital admissions was higher for those with TBI compared to the matched sample of those without a TBI in total and also within each demographic variable examined.

For *outpatient visits*, those with a TBI had a significantly higher percentage of at least one outpatient visit ($P < .0001$), and this was also true for patients of all ages ($P < .0001$), both males and females ($P < .0001$), all regions ($P < .0001$), both rural and urban residents ($P < .0001$), all insurance types ($P < .0001$), and for new diagnoses in the year following

the index encounter, for both children ($P < .0001$) and adults ($P = .0004$) compared to those in the non-TBI group. For *ED visits and hospital admissions*, those with a TBI had a significantly higher percentage, compared to those without a TBI, of overall ED visits in the year following the index encounter ($P < .0001$). This held for all ages ($P < .0001$), with larger effects (medium effect and above) for patients ≥ 25 years of age (Cohen's $d = 0.5$); both males and females ($P < .0001$), with a larger effect for females (Cohen's $d = 0.9$); all regions ($P < .0001$); both rural and urban residents ($P < .0001$); and all insurance types ($P < .0001$). And among those who had an ED visit, the proportion having a new diagnosis in the following year was also higher for both children and adults ($P < .0001$) with a TBI, compared to those without a TBI. The same patterns of significantly higher percentages were evident for *hospital admissions* for those with a TBI compared to those without a TBI.

New diagnoses

Table 4 presents the top 10 new diagnoses within 1 year of the initial encounter for both the TBI and non-TBI group, stratified by type of visit (outpatient or inpatient) and by children/adults. For *outpatient visits*, among children in the TBI group, the most common secondary diagnosis was headache (19.4%) followed by cough (16.1%). For adults in the TBI group, the most common secondary diagnosis was hypertension (22.4%), followed by headache (18.2%). For both children and adults with TBI, there were smaller percentages for post-concussive syndrome and other conditions such as anxiety disorder. The pattern for the top 10 new diagnoses within 1 year of the initial encounter for the non-TBI group was similar with the exclusion of post-concussive syndrome and the inclusion of nasal congestion among children and obesity among adults for outpatient visits. For *inpatient visits* (eg, hospital admissions) among both TBI and non-TBI groups, the top 10 new diagnoses were similar (but varied in order and percentage) and also included vomiting and suicidal ideations among children and nicotine dependence and shortness of breath among adults.

DISCUSSION

Using 2018 and 2019 claims and encounters data for commercially insured populations, this study examined longitudinal health outcomes 1-year post encounter date for those with a TBI diagnosis and 1 year post index date for matched patients. As hypothesized, compared to matched non-TBI controls, we observed that individuals with a TBI had higher health care utilization across all types of health care settings (outpatient and inpatient) and visit types (ED visits and hospital admissions). Within 1 year of the initial encounter, most patients with TBI (96.7%) had at least one outpatient visit, 28.5% had at least one ED visit, and 6.4% had at least one hospital admission. Across the characteristics studied, all utilization rates were higher for those with TBI than the matched non-TBI controls. Both children (70.7%) and adults (83.9%) who sustained a TBI had a higher percentage of new diagnoses within 1 year of the index date compared to individuals in the non-TBI group. While previous literature has studied these characteristics, they are limited by several factors including focusing on a local area or on a specific population and/or analyses of older data. This study addresses these gaps in knowledge by independently examining more recent data

from a large dataset across the lifespan as well as exploring various clinical settings, and identification of factors that increase health care utilization among patients with TBI.

Among adults and children with TBI in our study, higher health care utilization during the first year after injury is consistent with other TBI studies.^{9,18,29} Similar to prior studies,^{9,10,29} we found that having a TBI was associated with an increased prevalence of outpatient visits, ED visits, and hospital admissions across a wide range of patient and injury characteristics, including factors such as urbanicity, sex, and insurance. The relevance of these findings is highlighted by the many repercussions of high health care utilization, including direct and indirect financial costs.³⁰ While the present study did not examine health care costs, other studies have demonstrated the high cost of health care utilization among those with a TBI. For example, a comparable pediatric TBI study⁹ reported a higher cost of hospital admission for persons with TBI (median hospital charge roughly \$6000 more) than for those with non-TBI trauma admission, as well as higher mortality (7 times more) associated with TBI.

Additionally, our results showed that those who sustained a TBI had more new diagnoses (eg, headaches, post-concussive syndrome, incident mental health conditions such as anxiety disorder and suicidal ideation) within 1 year of the initial encounter compared to individuals in a non-TBI group. These findings can inform future examinations of comorbidities associated with TBI and aid the understanding of how health care, prevention strategies, and healthy behaviors may modify the presence and/or prevalence of these conditions. For example, these results may be useful for targeted interventions with distinct treatment approaches that can alter recovery trajectories. Additionally, this finding is consistent with many other studies revealing a strong association between TBI and medical and psychiatric comorbidities.^{12,31} The higher prevalence of new diagnoses has several potential consequences. First, the greater proportion of comorbidities may contribute to greater health care utilization discussed above and this may increase both societal and individual-level costs. Second, these comorbidities may contribute to or place the individual at increased risk of worse outcomes.³² Third, the consequences of additional comorbidities have been found to be associated with lower socioeconomic status,³³ which may have health care disparity implications. Fourth, there is evidence of a lack of a comprehensive framework in the United States to address TBI along the full continuum of care and across various health care settings.³⁴ These unmet service needs among individuals with TBI have been shown to change over time and vary by injury severity, time since injury, and service domain.^{35,36} For example, one study³⁵ demonstrated that unmet needs was highest in the domains of psychiatry, educational services, and speech therapy, while another study³⁶ demonstrated that needs changed over time (3 months vs 12 months after injury) as a function of individual, family, and injury characteristics. Similarly, evidence demonstrates a deficit in follow-up care as well.³⁷ For instance, less than half of patients received follow-up care 3 months post-TBI.¹¹ Ultimately, it is important for individuals with TBI to seek care and for health care providers to monitor the recovery of these individuals to help ensure that they receive needed services to decrease adverse health outcomes (such as new diagnoses) and help restore health after injury.

Limitations

There are some limitations to consider. First, for inclusion in the study, individuals had to have medical insurance. Having insurance and seeking medical attention may be influenced by several factors, such as age, gender, race, spoken language, health insurance coverage, income level, ease of access, and geography.³⁸ For example, individuals who do not have insurance or speak English experience barriers and are less likely to seek care^{39–41} and thus are more likely to have less representation in health care datasets. Additionally, MarketScan CCAE does not capture all medical insurance (eg, those who are uninsured or who have government insurance). Second, for our study, being in the TBI group is dependent on seeking medical care and receiving a TBI diagnosis, as the present study used ICD-10 TBI diagnosis to define the injury. Though ICD codes are sensitive for diagnosis of severe TBI,⁴² the use of ICD codes to define brain injury in general may result in under diagnosis.⁴³ Moreover, not all individuals with TBI seek health care evaluation for the injury and may remain undiagnosed for a TBI,^{44–46} especially for those that are mild. Thus, it may be the case that the TBI group in this study may be not capturing as many mild TBIs. This study captures those with an initial diagnosis of TBI by relying on the seventh character of the ICD-10-CM code. While many insurers require completion of billable codes up to 7 digits where appropriate, it is possible that a TBI that was not initial was captured within this studies definition due to incomplete coding. Additionally, some individuals in the comparison group may have had undiagnosed mild TBI in 2018, and by nature of the study design, those in the comparison group may have had a history of TBI that occurred prior to 2018. This may result in potential for misclassification bias and have attenuated the results. Third, diagnoses were categorized as new if no visit occurred for that ICD-10 code in the 3 months prior to the initial encounter. It is possible that some diagnoses classified in this study as new were actually made prior to the 3 month cut-point. Fourth, it is also vital to consider that ICD codes are primarily collected for billing rather than research purposes, and their use may be inconsistent, inaccurate, and incomplete.^{47–49} Fifth, MarketScan data are not nationally representative, and results cannot be generalized to the entire population of the United States, though they do comprise a very large convenience sample. Sixth, interpretation of higher health care utilization was not examined in detail. For example, patients who have been diagnosed with a new TBI and receive follow-up care following the injury may be a sign of good clinical care (eg, obtaining appropriate rehabilitation and care) or it may serve as a proxy for worse outcomes (eg, higher risk for comorbidities or increased cost). Thus, increased health care utilization should be interpreted with caution and not go beyond the scope of the study. Last, *causality* between TBI and health outcomes was not studied, rather association was.

Future research implications

The present findings of increased visits and new diagnoses within 1 year following TBI indicate future research needs. Examining these patterns over further years post-injury would be informative, as would the relationship of visits and new diagnoses with potential risk factors for adverse long-term health outcomes. Similar to Eliacin et al,¹⁰ this data source can be used to examine the proportion of super-utilizers and risks of super-utilization. Additionally, future research could explore the potential of proactive education and follow-up care to reduce new diagnoses and resource use, as well as examining health care

outcomes among those who are uninsured or who have government insurance, a critical area for future work given higher rates of TBI among those who are uninsured.⁵⁰

CONCLUSIONS

These results demonstrate that individuals with a TBI had higher health care utilization across several types of health care settings, types of visits, and demographic factors, compared to the non-TBI group. These findings indicate that people who sustain a TBI may have greater health care needs. It is important for providers to follow their patients with TBI closely and to consider the most effective systems to support patients with TBI in receiving follow-up care to improve outcomes.

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 (TBI) within 1 year of the index visit, MarketScan, the United States, 2019

	TBI		Non-TBI	
	n	% (95% CI)	n	% (95% CI)
Total	72 338		72 338	
Characteristics				
Age				
0–17	34 591	47.8 (47.5–48.2)	34 591	47.8 (47.5–48.2)
18–24	13 670	18.9 (18.6–19.2)	13 670	18.9 (18.6–19.2)
25–34	4935	6.8 (6.6–7.0)	4935	6.8 (6.6–7.0)
35–44	5496	7.6 (7.4–7.8)	5496	7.6 (7.4–7.8)
45–54	6483	9.0 (8.8–9.2)	6483	9.0 (8.8–9.2)
55+	7163	9.9 (9.7–10.1)	7163	9.9 (9.7–10.1)
Sex				
Male	36 569	50.6 (50.2–5.9)	36 569	50.6 (50.2–5.9)
Female	35 769	49.4 (49.1–49.8)	35 769	49.4 (49.1–49.8)
Region				
Northeast	16 443	22.7 (22.4–23.0)	16 443	22.7 (22.4–23.0)
North central	16 911	23.4 (23.1–23.7)	16 911	23.4 (23.1–23.7)
South	27 312	37.8 (37.4–38.1)	27 312	37.8 (37.4–38.1)
West	11 451	15.8 (15.6–16.1)	11 451	15.8 (15.6–16.1)
Unknown/missing	221	0.3 (0.3–0.3)	221	0.3 (0.3–0.3)
Urbanicity				
Rural	7326	10.1 (9.9–10.3)	7623	10.5 (10.3–10.8)
Urban	65 012	89.9 (89.7–90.1)	64 715	89.5 (89.2–89.7)
Insurance status				
Comprehensive	1816	2.5 (2.5–2.7)	1816	2.5 (2.5–2.7)
PPO	36 298	51.5 (5.1–51.8)	36 298	51.5 (5.1–51.8)
Other ^a	32 407	46.0 (45.6–46.3)	32 407	46.0 (45.6–46.3)

Abbreviations: TBI, traumatic brain injury; PPO, preferred provider organization; CI, confidence interval.

Note: Patients with a TBI were exact matched 1:1 to patients without a TBI on age, sex, region, mental health and substance abuse (MHSA) coverage indicator, insurance status, and month of index date to account for baseline differences in health care resource use. Therefore, counts and percentages are identical for non-TBI patients for these characteristics and are not shown here.

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Other plan type is defined as Health Maintenance Organization (HMO), Exclusive Provider Organization (EPO), Point of Service (POS) with capitation, Consumer-Driven Health Plans (CDHP) and High Deductible Health Plans (HDHP).^a

TABLE 2
Outcomes of patients with traumatic brain injury (TBI) and those without a TBI within 1 year of the TBI index visit, MarketScan, the United States, 2019

	TBI		Non-TBI	
	n	%	n	%
Total	72 338		72 338	
Outcomes				
Visits and admissions (within 1 year)				
Outpatient visits	69 972	96.7 (96.6–96.9)	62 294	86.1 (85.9–86.4)
ED visits	20 642	28.5 (28.2–28.9)	9478	13.1 (12.9–13.4)
Hospital admissions ^a	4621	6.4 (6.2–6.6)	1882	2.6 (2.5–2.7)
New diagnoses (within 1 year)				
Children ^b	24 465	70.7 (70.2–71.2)	16 928	48.9 (48.4–49.5)
Adults ^c	31 698	83.9 (83.6–84.3)	22 724	60.2 (59.7–60.7)

Abbreviation: TBI, traumatic brain injury.

Note: Patients with a TBI were exact matched 1:1 to patients without a TBI on age, sex, region, mental health and substance abuse (MHSa) coverage indicator, insurance status, and month of index date to account for baseline differences in health care resource use.

^aHospital admissions represent inpatient outcomes.

^bNew diagnoses as among the population of children, defined as 17 or younger. Examples of new diagnoses include: learning disorders, attention-deficit/hyperactivity disorder, speech/language problems, developmental delay, bone/joint/muscle problems, anxiety problem, etc.

^cNew diagnoses are among the population of adults, defined as 18 or older. Examples of new diagnoses include: physical (diabetes, stroke, hypertension, etc) and mental (alcoholism, drug addition, anxiety, etc) health conditions.

TABLE 3
Characteristics of outcomes in patients with traumatic brain injury (TBI) and those without a TBI within 1 year of the TBI index date by health care utilization, MarketScan, the United States, 2019

	Outpatient visits					
	TBI			Non-TBI		
	n	% (95% CI)	n	% (95% CI)	P-value	Effect size (Cohen's d ^b)
Total	69 972	96.7 (95.6–96.9)	62 294	86.1 (85.9–86.4)	<.0001	–0.4
Age						
0–17	33 799	97.7 (97.6–97.9)	30 601	88.5 (88.1–88.8)	<.0001	–0.4
18–24	12 833	93.9 (93.5–94.3)	10 640	77.8 (77.1–78.5)	<.0001	–0.5
25–34	4654	94.3 (93.7–95.0)	4006	81.2 (80.1–82.3)	<.0001	–0.4
35–44	5293	96.3 (95.8–96.8)	4687	85.3 (84.3–86.2)	<.0001	–0.4
45–54	6319	97.5 (97.1–97.9)	5784	89.2 (88.5–90.0)	<.0001	–0.3
55+	7074	98.8 (98.5–99.0)	6576	91.8 (91.2–92.4)	<.0001	–0.3
Sex						
Male	34 911	95.5 (95.3–95.7)	30 073	82.2 (81.8–82.6)	<.0001	–0.4
Female	35 061	98.0 (97.9–98.2)	32 221	90.1 (89.8–90.4)	<.0001	–0.3
Region						
Northeast	16 133	98.1 (97.9–98.3)	14 980	91.1 (90.7–91.5)	<.0001	–0.3
North central	16 390	96.9 (96.7–97.2)	14 519	85.9 (85.3–86.4)	<.0001	–0.4
South	26 310	96.3 (96.1–96.6)	23 321	85.4 (85.0–85.8)	<.0001	–0.4
West	10 924	95.4 (95.0–95.8)	9285	81.1 (80.4–81.8)	<.0001	–0.5
Unknown/missing	215	97.3 (95.1–99.4)	189	85.5 (80.8–91.2)	<.0001	–0.4
Urbanicity						
Rural	7007	95.6 (95.2–96.1)	6432	84.4 (83.6–85.2)	<.0001	–0.4
Urban	62 965	96.9 (96.7–97.0)	55 862	86.3 (86.1–86.6)	<.0001	–0.4
Insurance type						
Comprehensive	1736	95.6 (94.6–96.5)	1507	83.0 (81.3–84.7)	<.0001	–0.4
PPO	35 153	96.7 (96.5–96.9)	31 391	85.9 (85.5–86.3)	<.0001	–0.4
Other ^a	31 324	96.8 (96.7–97.0)	27 831	86.5 (86.1–86.8)	<.0001	–0.4
New diagnoses						

	Outpatient visits				
	TBI		Non-TBI		P-value
	n	% (95% CI)	n	% (95% CI)	
Children ^c	24 404	99.8 (99.7–99.8)	16 831	99.4 (99.3–99.5)	<.0001
Adults ^d	31 486	99.3 (99.2–99.4)	22 511	99.1 (98.9–99.2)	.0004
					Effect size (Cohen's d ^{ff})
					–0.1
					–0.03

	ED visits				Hospital admissions						
	TBI		Non-TBI		Effect size (Cohen's d) ^a	TBI		Non-TBI			
	n	% (95% CI)	n	% (95% CI)		P-value	n	% (95% CI)	n	% (95% CI)	P-value
Total	20 642	28.5 (28.2–28.9)	9478	13.1 (12.9–13.3)	<.0001	4621	6.4 (6.2–6.6)	1882	2.6 (2.5–2.7)	<.0001	–0.2
Age											
0–17	8310	24.0 (23.6–24.5)	4202	12.1 (11.8–12.5)	<.0001	834	2.4 (2.2–2.6)	475	1.4 (1.3–1.5)	<.0001	–0.1
18–24	4500	32.9 (32.1–33.7)	2117	15.5 (14.9–16.1)	<.0001	843	6.2 (5.8–6.6)	346	2.5 (2.3–5.8)	<.0001	–0.2
25–34	1628	33.0 (31.7–34.3)	672	13.6 (12.7–14.6)	<.0001	509	10.3 (9.5–11.2)	323	6.5 (5.9–7.2)	<.0001	–0.1
35–44	1765	32.1 (30.9–33.3)	692	12.6 (11.7–13.5)	<.0001	508	9.2 (8.5–10.0)	216	3.9 (3.4–4.4)	<.0001	–0.2
45–54	2101	32.4 (31.3–33.5)	848	13.1 (12.3–13.9)	<.0001	780	12.0 (11.2–12.8)	199	3.1 (2.6–3.5)	<.0001	–0.3
55+	2338	32.6 (31.6–33.7)	947	13.2 (12.4–14.0)	<.0001	1147	16.0 (15.2–16.9)	323	4.5 (4.0–5.0)	<.0001	–0.4
Sex											
Male	9835	26.9 (26.4–27.3)	4452	12.2 (11.8–12.5)	<.0001	2224	6.1 (5.8–6.3)	656	1.8 (1.7–1.9)	<.0001	–0.2
Female	10 807	30.2 (29.7–30.7)	5026	14.1 (13.7–14.4)	<.0001	2397	6.7 (6.4–7.0)	1226	3.4 (3.2–3.6)	<.0001	–0.1
Region											
Northeast	4387	26.7 (26.0–27.4)	2077	12.6 (12.1–13.1)	<.0001	961	5.8 (5.5–6.2)	432	2.6 (2.4–2.9)	<.0001	–0.2
North central	5170	30.6 (29.9–31.3)	2484	14.7 (14.2–15.2)	<.0001	1119	6.6 (6.2–7.0)	471	2.8 (2.5–3.0)	<.0001	–0.2
South	8084	29.6 (29.1–30.1)	3677	13.5 (13.1–13.9)	<.0001	1897	6.9 (6.6–7.2)	719	2.6 (2.4–2.8)	<.0001	–0.2
West	2944	25.7 (24.9–26.5)	1212	10.6 (10.0–11.1)	<.0001	636	5.6 (5.1–6.0)	259	2.3 (2.0–2.5)	<.0001	–0.2
Unknown/missing	57	25.8 (20.0–31.6)	28	12.7 (8.2–17.1)	.0004	8	3.6 (1.1–6.1)	1	0.5 (–0.4–1.3)	.0184	–0.2
Urbanicity											
Rural	2389	32.6 (31.5–33.7)	1196	15.7 (14.9–16.5)	<.0001	498	6.8 (6.2–7.4)	198	2.6 (2.2–3.0)	<.0001	–0.2
Urban	18 253	28.01 (27.7–28.4)	8282	12.8 (12.5–13.1)	<.0001	4123	6.3 (6.2–6.5)	1684	2.6 (2.5–2.7)	<.0001	–0.2
Insurance type											
Comprehensive	665	36.6 (34.4–38.8)	315	17.3 (15.6–19.1)	<.0001	191	10.5 (9.1–11.9)	55	3.0 (2.2–3.8)	<.0001	–0.3

	ED visits						Hospital admissions					
	TBI			Non-TBI			TBI			Non-TBI		
	n	% (95% CI)	n	% (95% CI)	P-value	Effect size (Cohen's d) ^a	n	% (95% CI)	n	% (95% CI)	P-value	Effect size (Cohen's d) ^a
PPO	10 340	28.0 (27.5–28.5)	4764	12.9 (12.5–13.2)	<.0001	–0.4	2341	6.0 (5.8–6.3)	978	2.5 (2.3–2.6)	<.0001	–0.2
Other ^b	9066	28.5 (28.0–29.0)	4165	13.1 (12.8–13.5)	<.0001	–0.4	1959	6.4 (6.2–6.7)	801	2.7 (2.5–2.9)	<.0001	–0.2
New diagnoses												
Children ^c	7365	30.1 (29.5–30.7)	3373	19.9 (19.3–20.5)	<.0001	–0.2	819	3.3 (3.1–3.6)	452	2.7 (2.4–2.9)	.0001	–0.04
Adults ^d	11 753	37.1 (36.5–37.6)	4681	20.6 (20.1–21.1)	<.0001	–0.4	3743	11.8 (11.5–12.2)	1253	5.5 (5.2–5.8)	<.0001	–0.2

Abbreviations: TBI, traumatic brain injury; CI, confidence interval.

Note: Patients without a TBI were randomly assigned an index date within 2018 that matched patients with a TBI, the index date was the date that the matched TBI patient was seen for the TBI.

^aEffect sizes were also computed for each t-test using Cohen's d and interpreted in accordance with Cohen (Cohen, 1988) in order to determine the associations' practical significance. An r of 0.2 represents a small effect size, an r of 0.5 represents a medium effect size, and an r of 0.8 represents a large effect size.

^bOther plan type is defined as Health Maintenance Organization (HMO), Exclusive Provider Organization (EPO), Point of Service (POS) with capitation, Consumer-Driven Health Plans (CDHP) and High Deductible Health Plans (HDHP).

^cNew diagnoses as among the population of children, defined as 17 or younger. Examples of new diagnoses include: learning disorders, attention-deficit/hyperactivity disorder, speech/language problems, developmental delay, bone/joint/muscle problems, anxiety problem, etc.

^dNew diagnoses as among the population of adults, defined as 18 or older. Examples of new diagnoses include: physical (diabetes, stroke, hypertension, etc) and mental (alcoholism, drug addition, anxiety, etc) health conditions.

TABLE 4

Top 10 new diagnoses for type of visit in child and adult patients with traumatic brain injury (TBI) and those without a TBI within 1 year of the TBI index date, MarketScan, the United States, 2019

Diagnosis	Child ^a			Adult ^b		
	TBI		Non-TBI		TBI	
	ICD-10-CM	n (%)	ICD-10-CM	n (%)	ICD-10-CM	n (%)
Outpatient						
1	Headache (R51)	4585 (19.4)	Cough (R05)	2755 (16.9)	Essential (primary) hypertension (I10)	6880 (22.4)
2	Cough (R05)	3815 (16.1)	Anxiety disorder, unspecified (F419)	1381 (8.5)	Headache (R51)	5597 (18.2)
3	Post-concussive syndrome (F0781)	2255 (9.5)	Body mass index (BMI) pediatric, greater than or equal to 95th percentile for age (Z6854)	1292 (7.9)	Anxiety disorder, unspecified (F419)	4776 (15.5)
4	Anxiety disorder, unspecified (F419)	2253 (9.5)	Generalized anxiety disorder (F411)	1261 (7.7)	Cough (R05)	3888 (12.6)
5	Generalized anxiety disorder (F411)	1992 (8.4)	Attention-deficit hyperactivity disorder, combined type (F902)	1205 (7.4)	Other fatigue (R5383)	3784 (12.3)
6	Other fatigue (R5383)	1682 (7.1)	Headache (R51)	1093 (6.7)	Post-concussive syndrome (F0781)	3678 (12.0)
7	Attention-deficit hyperactivity disorder, combined type (F902)	1555 (6.6)	Attention-deficit hyperactivity disorders (F900)	916 (5.6)	Generalized anxiety disorder (F411)	3676 (11.9)
8	Pain in right knee (M25561)	1365 (5.8)	Other fatigue (R5383)	910 (5.6)	Major depressive disorder, single episode, unspecified (F329)	2986 (9.7)
9	Body mass index (BMI) pediatric, greater than or equal to 95th percentile for age (Z6854)	1320 (5.6)	Attention-deficit hyperactivity disorder, unspecified type (F909)	733 (4.5)	Hypothyroidism, unspecified (E039)	2518 (8.2)
10	Attention-deficit hyperactivity disorders (F900)	1283 (5.4)	Nasal congestion (R0981)	728 (4.5)	Obstructive sleep apnea (adult) (pediatric) (G4733)	2204 (7.2)
Inpatient^c						
1	Headache (R51)	954 (19.9)	Headache (R51)	260 (11.7)	Essential (primary) hypertension (I10)	2428 (23.1)
2	Nausea with vomiting, unspecified (R112)	483 (10.1)	Cough (R05)	231 (10.4)	Headache (R51)	2140 (20.4)

Diagnosis	Child ^a						Adult ^b			
	TBI			Non-TBI			TBI		Non-TBI	
	ICD-10-CM	n (%)	ICD-10-CM	ICD-10-CM	n (%)	ICD-10-CM	ICD-10-CM	n (%)	ICD-10-CM	n (%)
3	Major depressive disorder, single episode, unspecified (F329)	424 (8.9)	Nausea with vomiting, unspecified (R112)	Nausea with vomiting, unspecified (R112)	218 (9.8)	Anxiety disorder, unspecified (F419)	Anxiety disorder, unspecified (F419)	1432 (13.6)	Nausea with vomiting, unspecified (R112)	428 (10.6)
4	Vomiting, unspecified (R1110)	393 (8.2)	Major depressive disorder, single episode, unspecified (F329)	Major depressive disorder, single episode, unspecified (F329)	217 (9.7)	Major depressive disorder, single episode, unspecified (F329)	Major depressive disorder, single episode, unspecified (F329)	1246 (11.9)	Anxiety disorder, unspecified (F419)	397 (9.9)
5	Cough (R05)	375 (7.8)	Suicidal ideations (R45851)	Suicidal ideations (R45851)	215 (9.6)	Nausea with vomiting, unspecified (R112)	Shortness of breath (R0602)	1042 (9.9)	Shortness of breath (R0602)	348 (8.6)
6	Anxiety disorder, unspecified (F419)	372 (7.8)	Anxiety disorder, unspecified (F419)	Anxiety disorder, unspecified (F419)	173 (7.8)	Nicotine dependence, cigarettes, uncomplicated (F17210)	Nicotine dependence, cigarettes, uncomplicated (F17210)	953 (9.1)	Nicotine dependence, cigarettes, uncomplicated (F17210)	325 (8.1)
7	Suicidal ideations (R45851)	371 (7.8)	Nausea (R110)	Nausea (R110)	133 (6.0)	Shortness of breath (R0602)	Shortness of breath (R0602)	931 (8.9)	Major depressive disorder, single episode, unspecified (F329)	311 (7.7)
8	Nausea (R110)	357 (7.5)	Vomiting, unspecified (R1110)	Vomiting, unspecified (R1110)	132 (5.9)	Nausea (R110)	Nausea (R110)	815 (7.8)	Cough (R05)	272 (6.8)
9	Attention-deficit hyperactivity disorder, unspecified type (F909)	285 (6.0)	Shortness of breath (R0602)	Shortness of breath (R0602)	122 (5.5)	Cough (R05)	Cough (R05)	730 (6.9)	Nausea (R110)	248 (6.2)
10	Post-concussive syndrome (F0781)	226 (4.7)	Attention-deficit hyperactivity disorder, unspecified type (F909)	Attention-deficit hyperactivity disorder, unspecified type (F909)	121 (5.4)	Nicotine dependence, unspecified, uncomplicated (F17200)	Nicotine dependence, unspecified, uncomplicated (F17200)	617 (5.9)	Nicotine dependence, unspecified, uncomplicated (F17200)	213 (5.3)

Note: Patients without a TBI were randomly assigned an index date within 2018 that matched patients with a TBI, the index date was the date that the matched TBI patient was seen for the TBI.

^aChildren are defined as 17 or younger.

^bAdults are defined as 18 or older.

^cInpatient visits are comprised of hospital admissions.